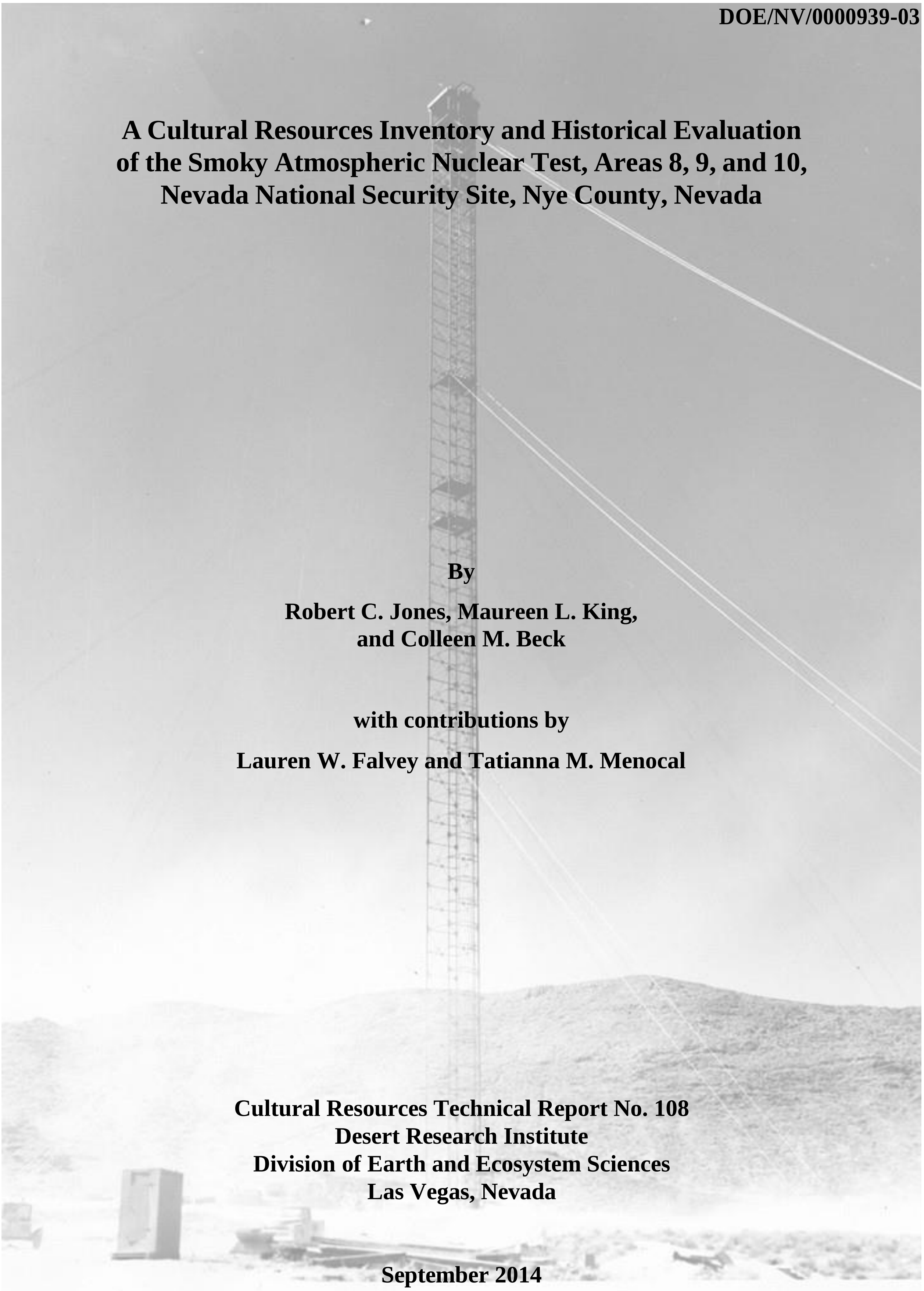

DOE/NV/0000939-03

A Cultural Resources Inventory and Historical Evaluation of the Smoky Atmospheric Nuclear Test, Areas 8, 9, and 10, Nevada National Security Site, Nye County, Nevada

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Cultural Resources Technical Report No. 108
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Prepared for
U.S. Department of Energy
National Nuclear Security Administration
Nevada Field Office
Las Vegas, Nevada

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EXECUTIVE SUMMARY

This report presents the results of a National Historic Preservation Act Section 106 cultural resources inventory and historical evaluation of the 1957 Smoky atmospheric test location on the Nevada National Security Site (NNSS). The Desert Research Institute (DRI) was tasked to conduct a cultural resources study of the Smoky test area as a result of a proposed undertaking by the Department of Energy Environmental Management. This undertaking involves investigating Corrective Action Unit (CAU) 550 for potential contaminants of concern as delineated in a Corrective Action Investigation Plan. CAU 550 is an area that spatially overlaps portions of the Smoky test location.

Smoky, T-2c, was a 44 kt atmospheric nuclear test detonated at 5:30 am on August 31, 1957, on top of a 213.4 m (700 ft) 200 ton tower (T-2c) in Area 8 of the NNSS. Smoky was a weapons related test of the Plumbbob series (number 19) and part of the Department of Defense Exercise Desert Rock VII and VIII. The cultural resources effort involved the development of a historic context based on archival documents and engineering records, the inventory of the cultural resources in the Smoky test area and an associated military trench location in Areas 9 and 10, and an evaluation of the National Register eligibility of the cultural resources. The inventory of the Smoky test area resulted in the identification of structures, features, and artifacts related to the physical development of the test location and the post-test remains. The Smoky test area was designated historic district D104 and coincides with a historic archaeological site recorded as 26NY14794 and the military trenches designed for troop observation, site 26NY14795. Sites 26NY14794 and 26NY14795 are spatially discrete with the trenches located 4.3 km (2.7 mi) southeast of the Smoky ground zero. As a result, historic district D104 is discontiguous and in total it covers 151.4 hectares (374 acres).

The Smoky test location, recorded as historic district D104 and historic sites 26NY14794 and 26NY14795, is the best preserved post-shot atmospheric nuclear tower test at the NNSS and possibly in the world. It is of local, national, and international importance due to nuclear testing's pivotal role in the Cold War between the United States and the former Soviet Union. The district and sites are linked to the historic theme of atmospheric nuclear testing. D104 retains aspects of the engineering plan and design for the Smoky tower, instrument stations used to measure test effects, German and French personnel shelters, and military trenches. A total of 33 structures contribute to the significance of D104. Artifacts and features provide significant post-test information. Historic district D104 (discontiguous) and historic site 26NY14794 (the Smoky test area) are eligible for listing on the NRHP under Criteria A, B, C, and D. The historic site 26NY14795 (the Smoky military trenches) is eligible for listing under Criteria A, C, and D.

Several items have been identified for removal by the CAU 550 investigation. However, none of them is associated with the Smoky atmospheric test, but with later activities in the area. The military trenches are not part of CAU 550 and no actions are planned there. A proposed closure of the Smoky test area with restrictions will limit access and contribute to the preservation of the cultural resources. It is recommended that the Smoky historic district and sites be included in the NNSS cultural resources monitoring program.

ACKNOWLEDGMENTS

This research was conducted for the Soils Activity. It was under the direction of Tiffany Lantow and Kevin Cabble, U.S. Department of Energy, Office of Environmental Management, and Linda Cohn, Cultural Resources Manager for the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office. Colleen M. Beck, Desert Research Institute, was project director and the cultural resources field work was conducted by Desert Research Institute archaeologists Colleen M. Beck, Barbara A. Holz, Justin DeMaio, and Robert C. Jones.

A great thank you to all the Navarro-Intera personnel for providing support for this project including: Patrick Matthews, Grant Evenson, and Dawn Peterson. We would like to thank Harold Rarrick, technical consultant at Sandia National Laboratory, and Cliff Olsen, Lawrence Livermore National Laboratory, for providing valuable information about the test. Byron Ristvet, Containment Scientist for DTRA, provided an interview on the history of the Smoky test. Martha DeMarre, National Security Technologies, provided historic documents and photographs on file at the Nuclear Testing Archive, Las Vegas. Loretta Bush at the NNSA/NSO Technical Library, North Las Vegas, obtained key scientific reports for the Smoky test. Priscilla Diolazo provided assistance with the Scientific and Technical Information Archival & Retrieval System - Unclassified at the Defense Threat Reduction Information Analysis Center, Kirtland Air Force Base, New Mexico. Troy Leonard, National Security Technologies, provided engineering drawings on file at the Archives and Records Center, Mercury, Nevada.

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INTRODUCTION

The U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) requested the Desert Research Institute conduct a historical evaluation of the Smoky atmospheric test location in Area 8 of the Nevada National Security Site (NNSS), Nye County, Nevada. This study was conducted to comply with Section 106 of the National Historic Preservation Act of 1966 as amended, and involved recording the Smoky atmospheric test site, identifying historic properties eligible to the National Register of Historic Places (NHRP), and assessing possible effects from a proposed undertaking in the area.

Smoky was a 44 kt atmospheric nuclear test detonated at 5:30 am on August 31, 1957, on top of a 213.4 m (700 ft) 200 ton tower (T-2c) in Area 8 of the NNSS. Smoky was a weapons related test of the Plumbbob series (number 19) and part of the Department of Defense (DOD) Exercise Desert Rock VII and VIII. Originally scheduled for August 19, 1957, the Smoky test was delayed until the morning of August 31, 1957. The three main federal agencies participating in the Smoky test were the U.S. Atomic Energy Commission (AEC) with the two weapons laboratories, Los Alamos National Laboratory (LANL) and Lawrence Livermore National Laboratory (LLNL); the Federal Civil Defense Administration (FCDA) through its Civil Effects Test Group (CETG); and the DOD through the Armed Forces Special Weapons Project (AFSWP).

Corrective Action Unit (CAU) 550 is being investigated by Department of Energy (DOE) Environmental Management (EM) to identify radiological and chemical contaminants under a Corrective Action Investigation Plan (CAIP) that includes part of the Smoky test area (DOE/NV 2012). This plan was developed in accordance with the Federal Facility Agreement and Consent Order (1996, as amended) agreed to by the State of Nevada; DOE Environmental Management; DOD; and DOE Legacy Management. As part of this investigation, when contaminants of concern were identified, EM looked at corrective action alternatives for the situation. The alternatives considered were: 1) no further action, 2) clean closure, or 3) closure in place. The latter two options involve remediation either by removing materials or closing the area with use restrictions, or both.

This report documents the results of a cultural resources inventory of approximately 51 hectares (126 acres) surrounding the Smoky atmospheric test ground zero and the historical evaluation of the Smoky atmospheric test and its associated structures and historic archaeological sites. This includes military trenches to the southeast of Smoky test location in Areas 9 and 10, constructed for observation of the test by military troops (Figure 1). For the cultural resources study, the boundary of the area of potential effect (APE) is the geographic area of the historic Smoky site that could be affected by the proposed undertaking (Figure 2). The area for the APE is 59 hectares (146 acres) and incorporates items identified as corrective action sites considered to be potential sources of contamination. Eight hectares (19.8 acres) of the APE were not inventoried due to radiological concerns. The Smoky trenches are geographically separate and outside the area of potential effect.

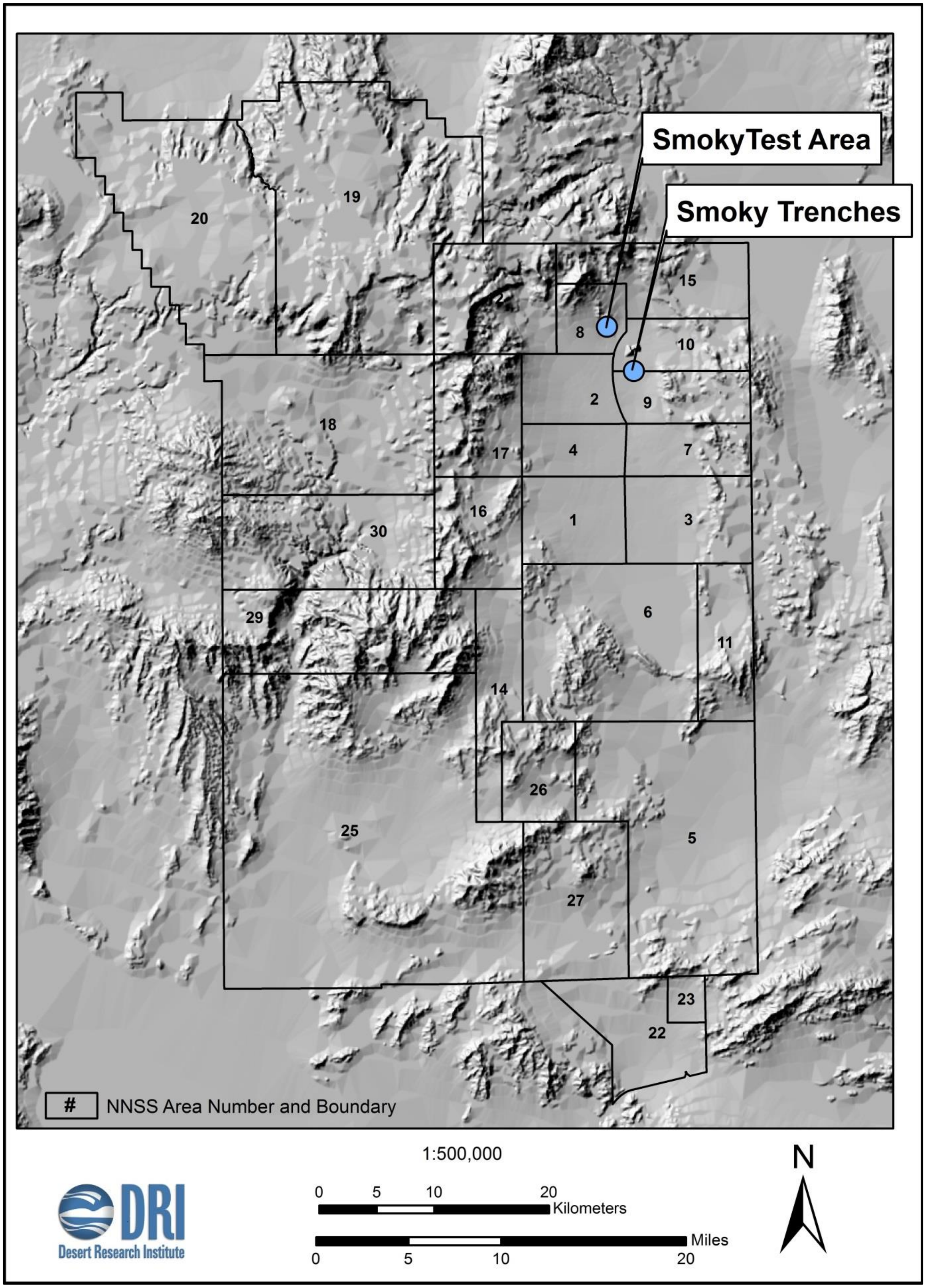

Figure 1. Location of areas investigated for the Smoky project on the NNSS.

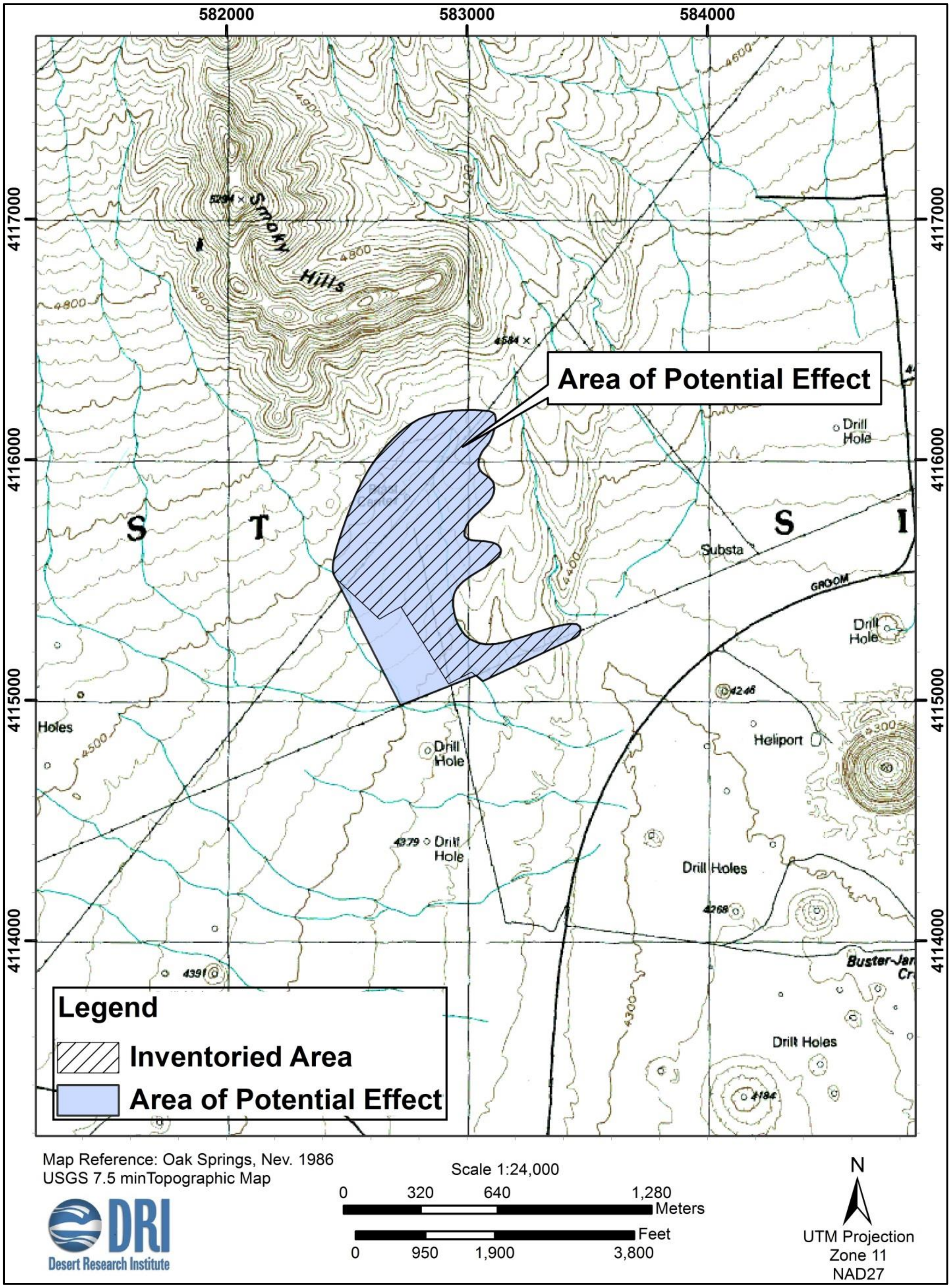

Figure 2. Smoky project map showing area of potential effect and inventoried area.

The historic Smoky atmospheric test site (26NY14794) and the military trenches for troop participation (26NY14795) have also been recorded as historic district D104 (discontiguous) (Figure 3). The total area for historic district D104 is 151.4 hectares (374 acres) and corresponds with the boundaries of historic sites 26NY14794 and 26NY14795 (Figure 4). The area for historic site 26NY14794, the Smoky test area, is 140 hectares (346 acres) of which the 51 hectares (126 acres) within the APE were inventoried. The site boundary is based on information obtained from historic documents along with field observations of artifacts and features. The total site area was not examined due to radiological and time constraints. Historic site 26NY14795, the military trenches (S922), is 4.3 km (2.7 miles) southeast of the Smoky ground zero. This site covers 11.4 hectares (28 acres) and this entire area was inventoried for this project.

Hectares (acres) for the Smoky investigation:

Site 26NY14794	140 hectares	(346 acres)
Site 26NY14795 (trenches)	11.4 hectares	(28 acres)
Historic district D104	151.4 hectares	(374 acres)
Area of Potential Effect	59 hectares	(146 acres)
Inventoried portion of APE	51 hectares	(126 acres)

The Smoky historic district and historic archaeological sites are of local, national, and international importance. Nuclear testing is one of the themes stated in the Nevada Comprehensive Preservation Plan (White et al. 1991) provided by the Nevada State Historic Preservation Office. The material culture at Smoky is complex. Most of the artifacts are near ground zero but some are hundreds of meters away. The artifacts consist of layers of twisted, broken, and melted metal tower beams and supports, machinery, and other materials. In addition to these artifacts, recorded structures are components of the tower, instrument stations, a battery vault, a Ballistic Research Laboratory structure, and French and German underground concrete shelters. Within the inventoried site area, DRI recorded 1 building (a trailer not associated with the Smoky test), 35 structures, and 14 features. The military trench area consists of a series of seven parallel linear trenches built for military training during the Smoky test. Most of the cultural materials are unmodified and undisturbed since the test.

The Smoky test location, designated historic district D104 (discontiguous), contributing structures, and two historic archaeological sites 26NY14794 and 26NY14795, are united historically by the Smoky engineering plan, the physical development of the test location, and the post-test remains. Smoky is the best preserved post-shot atmospheric nuclear tower testing location on the NNSS and possibly in the world. The NNSS, formerly the Nevada Test Site, was the United States continental nuclear weapons testing ground during the Cold War with the former Soviet Union. D104 is eligible to the NRHP under Criteria A, B, C, and D.

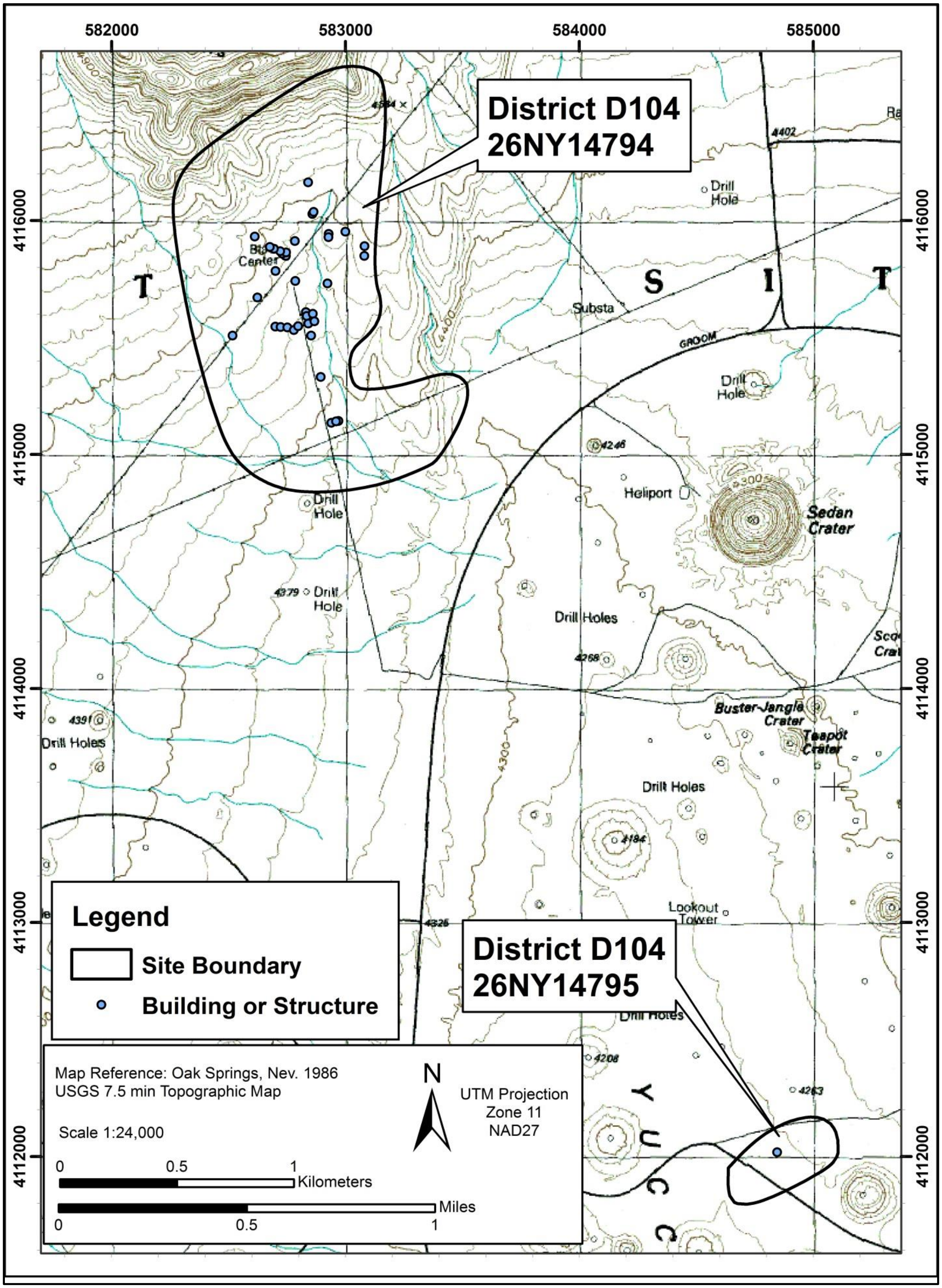

Figure 3. Map showing discontiguous historic district D104, historic sites 26NY14794 and 26NY14795, and locations of buildings and structures.

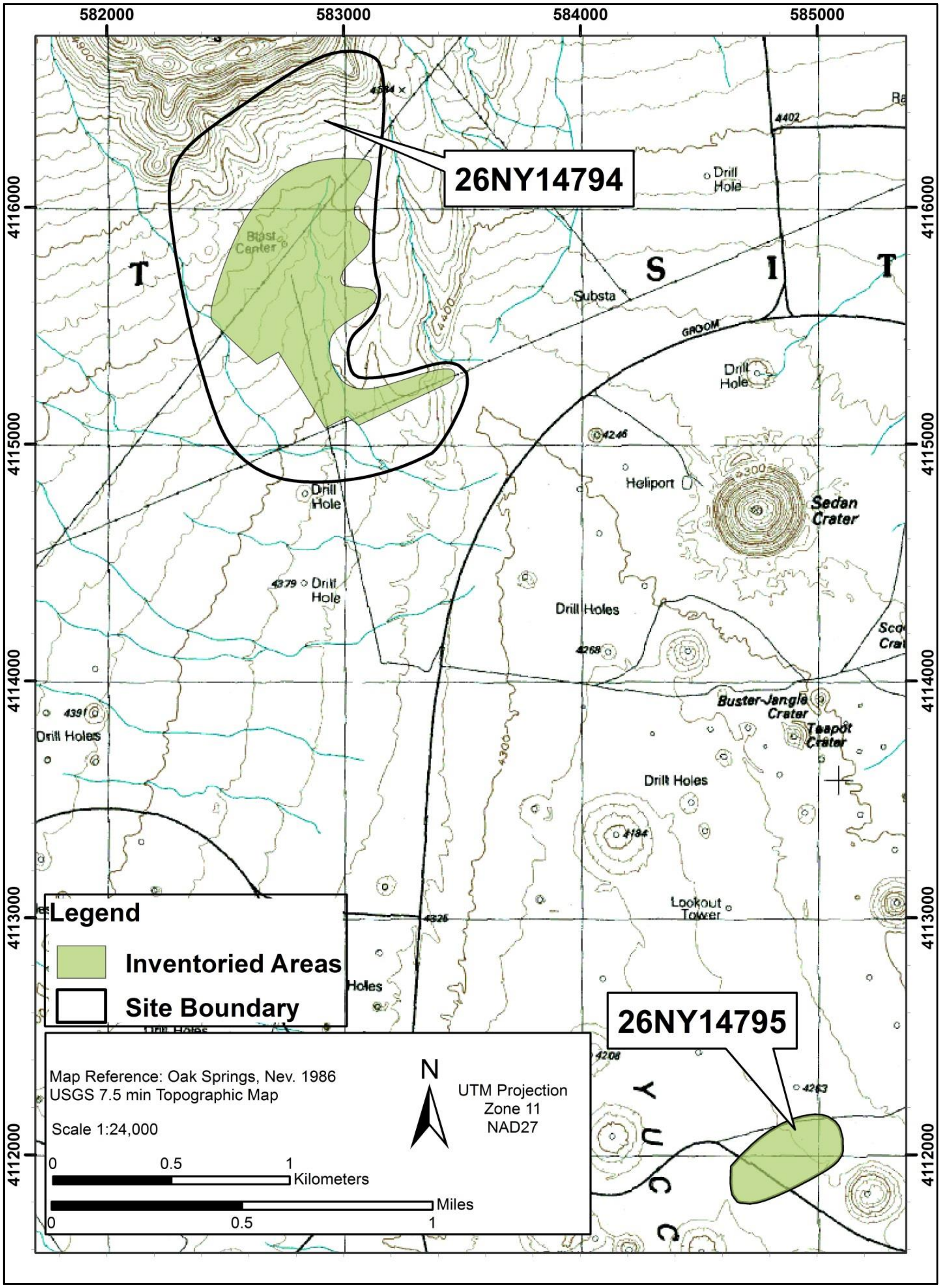

Figure 4. Map of historic sites 26NY14794 and 26NY14795 showing site boundaries and inventoried areas.

As a result of the proposed undertaking, a small number of items within site 26NY14794 are scheduled for removal (Table 1, Figure 5). Removal of items will occur in a very limited area of the historic site. The three 10-gallon drums (CAS 08-22-08) are empty and dispersed across a 3 m x 1.2 m (10 ft x 4 ft) area. Three intact batteries with lead grid plates and a broken battery with lead grid plates (CAS 08-24-07) occur in a 1.8 m x 0.91 m (6 ft x 3 ft) area. Another set of three batteries are mixed with other materials including lead grid plates, small electrical equipment, and unidentified metal pieces (CAS 08-24-08) and are in a low pile within a 1.8 m x 1.8 m (6 ft x 6 ft) area. Removal of these items will not disturb other resources, features, or artifacts, and will not have an adverse effect on the Smoky property as these items are not contemporary with the Smoky atmospheric test, but with subsequent activities in the area. Therefore, the items scheduled for removal do not relate to the significance of the property. However, removal or disturbance of cultural materials associated with the Smoky test would compromise the integrity of the Smoky historic district, resulting in an adverse effect requiring mitigation activities. The proposed closure of the area with use restrictions will limit access and contribute to the preservation of the area. It is recommended that the Smoky historic district and sites be included in the NNSS cultural resources monitoring program.

The following sections of this report are the environmental setting, research design and methods, historic context, research questions, the description of the cultural resources, and the summary with the National Register eligibility evaluations.

Table 1. Corrective Action Sites with Items Scheduled for Removal.

Corrective Action Number	**Description**	**Action**
08-22-08	Drums (n=3), 10-gal metal in high contamination area (not surveyed).	Remove
08-24-07	Batteries with lead grid plates (n=3) and a broken battery with lead grid plate.	Remove
08-24-08	Batteries with lead grid plates (n=3) mixed with other items including scrap metal and small electrical equipment pieces.	Remove

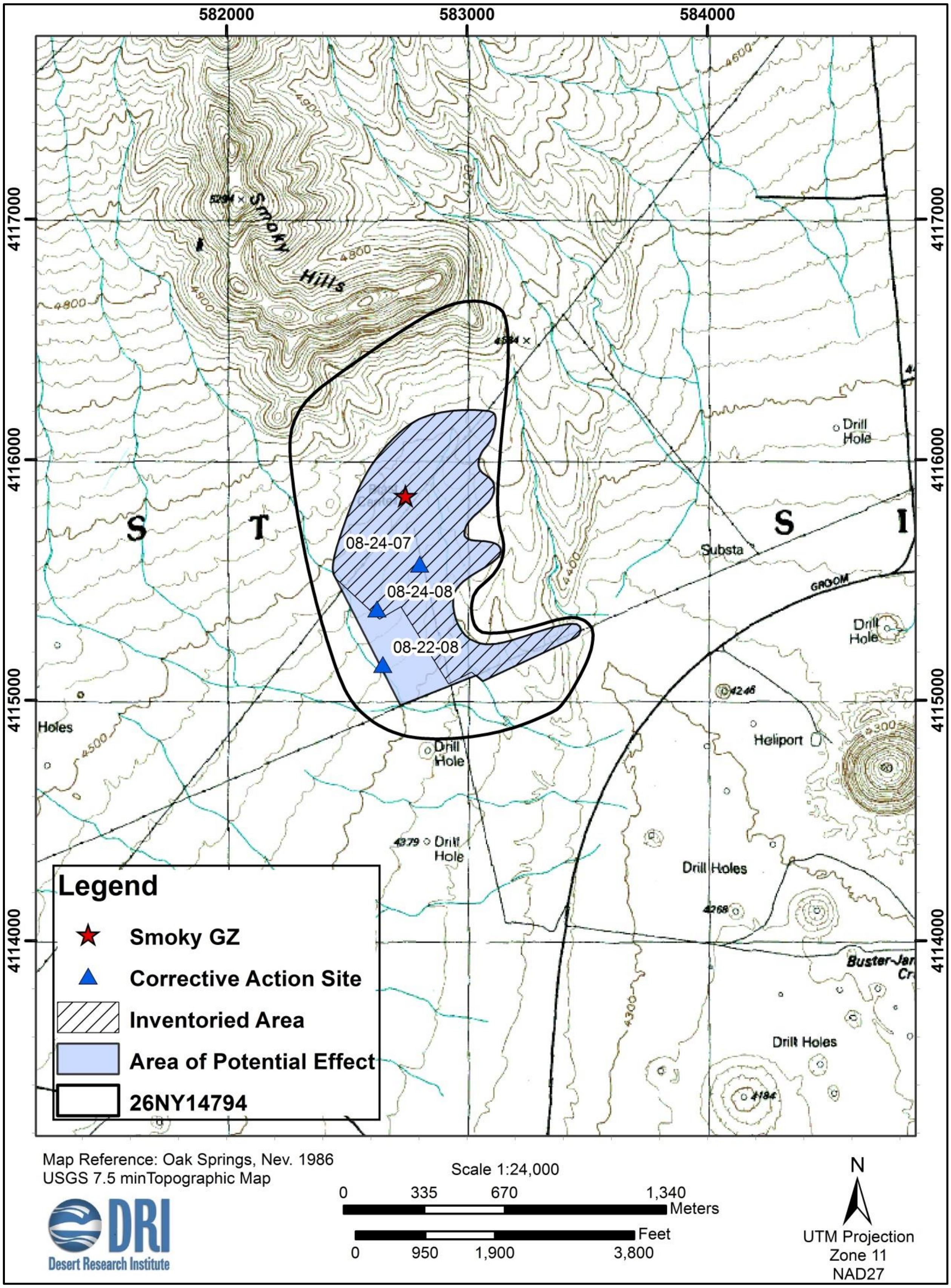

Figure 5. Location of corrective action sites, area of potential effect, inventoried area, and site 26NY14794 boundary.

ENVIRONMENTAL SETTING

LOCATION

The NNSS, a federal facility restricted to the public, is approximately 97 km (60 miles) northwest of Las Vegas by way of U.S. Highway 95 and lies within the southern portion of the Great Basin, characterized by high mountain ranges interspersed by valleys and bolsons (Dohrenwend 1987). Climate is generally of limited precipitation, low humidity, and extreme daily temperature ranges. The lower elevations of the NNSS have dry, hot summers and mild winters, while the higher elevations have increased precipitation and lower temperatures. Most of the precipitation is in the form of snow and winter rainstorms, with an occasional storm during the fall and spring. Rainstorms do occur in the summer, but are rare. Permanent natural water sources for the NNSS are springs and seeps, and ones nearest the project area are Whiterock Spring at 5.9 km (3.7 miles) to the northwest, Tub Spring at 6.5 km (4 miles) to the northeast, and Captain Jack Spring at 9.3 km (5.8 miles) to the southwest.

The Smoky project areas are reached from Mercury, located toward the southeast corner of the NNSS, by initially traveling north on the Mercury Highway for about 34 km (21 miles), over Checkpoint Pass, through Frenchman Flat, over Yucca Pass, and into Yucca Flat to the Tippipah Highway intersection. Continue north on Mercury Highway another 19.7 km (12.3 miles) to the intersection of the 2-05 road. From this point turn right on the 10-03 road and travel 1.7 km (1.08 mile) to the southern portion of the project area, the trenches (Areas 9 and 10). At the intersection of the 2-05 road, turn on to the 2-05 road and proceed 2.9 km (1.8 miles) to Circle Road. Travel north on Circle Road 2.4 km (1.5 miles) to the 2-07 road and travel west 1.7 km (1 mile) to an unnumbered dirt road. Turn north and travel 2.3 km (1.5 miles) to a powerline road. Turn east and travel 0.2 km (0.7 mile) along the powerline road to a fence. The Smoky test location (Area 8) is 360 m (0.2 mile) to the east (Figure 2).

The NNSS is located in an area of southern Nevada that lies between the Great Basin Desert and the Mojave Desert (Ostler et al. 2000). Within the NNSS are both desert types, with the northern end of the site being Great Basin Desert and the southern end of the site being Mojave Desert (Ostler et al. 2000:1-4). A transitional area between the two deserts has been created by gradients in precipitation, temperature, and soils (Ostler et al. 2000:1-4). Unique combinations of physical site conditions have created different vegetation patterns on the NNSS that have challenged development of a simple classification system (Ostler et al. 2000:1-4).

The Smoky test location, at an elevation of 1,365 m (4,479 ft), and the trench area, at an elevation of 1,298 m (4,260 ft), are at the northern end of Yucca Flat, a large closed valley with Yucca Lake situated at the lowest point. This area is generally flat with the lowest point of the playa at 1,195 m (3,919 ft). Hogback Ridge separates Yucca Flat from Frenchman Flat further to the south. Yucca Flat is bounded on the north by Oak Springs Butte and Quartzite Ridge that are at the southern end of the Belted Range. On the northwest, Yucca Flat is bounded by the Eleana Range and on the west by Syncline Ridge, Mine Mountain, and CP Hills. The southeastern edge is the Massachusetts Range and the eastern border is the Halfpint Range where the Rhyolite Hills separate Yucca Flat from Emigrant Valley and Groom Lake.

GEOLOGY

Sediments in the area are generally alluvial, as streams bring eroded materials from the Belted, Eleana, and Massachusetts ranges. Sediments in Yucca Flat are coarse and poorly sorted becoming finer toward the center of the valley (Reno and Pippin 1985). Other sources of sediments are talus and colluvium, shoreline, and aeolian. Two major groups of deposits have been defined (Fernald et al. 1968). The playa deposits are late Pleistocene and Holocene in age with some of the terrace and fan deposits being much older, possibly Tertiary. However, there is no evidence to indicate the valley supported a pluvial lake during the Pleistocene as in other nearby valleys, such as the Groom Lake east of the NNSS or the Kawich, Gold Flat, and Mud lakes to the north (Grayson 1993: Table 5-2; Mifflin and Wheat 1979). Soils of the NNSS are similar to those of surrounding areas and include Aridisols and Entisols (Peterson 1988; Taylor 1986; Wesling et al. 1992; Whitney et al. 1986). The degree of soils development reflects their age, and the soils types and textures reflect their origin. Entisols generally form on steep mountain slopes and in stream valleys along active washes. Aridisols commonly are older and form on more stable alluvial fans and stream terraces. At the Smoky test location, three alluvial units and one colluvial unit have been mapped (Figure 6 and 7) (Slate et al. 1999: 5-7). The majority of the area is within early Holocene to Pleistocene intermixed and interbedded alluvial deposits. The geologic units are:

Qay Young alluvial deposits (Holocene) - Gravel, sand, and silt that is intermixed and interbedded. Grayish brown, pale yellowish brown, light brownish gray to light gray, unconsolidated to poorly consolidated, poorly to moderately well sorted, nonbedded to well bedded, locally cross-bedded. Clasts are commonly angular to subrounded; locally well rounded. Clasts commonly less than 0.5 m in diameter, but as much as 2 m in diameter at and near base of steep slopes, and close to mountain fronts. Along large alluvial channels, such as Fortymile Wash, boulders are found several kilometers from the mountain front. Sand and silt present as matrix and lenses; rarely form continuous beds. Surface commonly is irregular; bar-and-swale topography and braided channels are common. In places, forms extensive thin sheets of sand with flat, smooth surfaces. Little or no pavement, varnish, or soil development except near dust sources. Maximum thickness about 10 m.

Qai Intermediate alluvial deposits (early Holocene and Pleistocene) – Gravel, sand, and silt; intermixed and interbedded, light gray, pinkish gray, and yellowish to grayish brown, weakly to moderately well consolidated. Clasts are unsorted to moderately well sorted, nonbedded to well bedded, angular to rounded. Clasts commonly less than 0.5 m in diameter, but locally as much as 2 m in diameter; matrix is sandy to silty. Sand is discontinuously to moderately well bedded, locally crossbedded, moderately well sorted; commonly gravelly and locally silty. Surface is planar with moderately packed to densely packed pavement; pavement clasts are moderately to well varnished. In places, thin eolian sand deposits mantle the surface. Soil development varies from a cambic B horizon and a stage I to II carbonate horizon to an argillic B horizon and an approximately 1-m-thick, stage III to IV carbonate horizon. Thickness less than 1 m to 10 m.

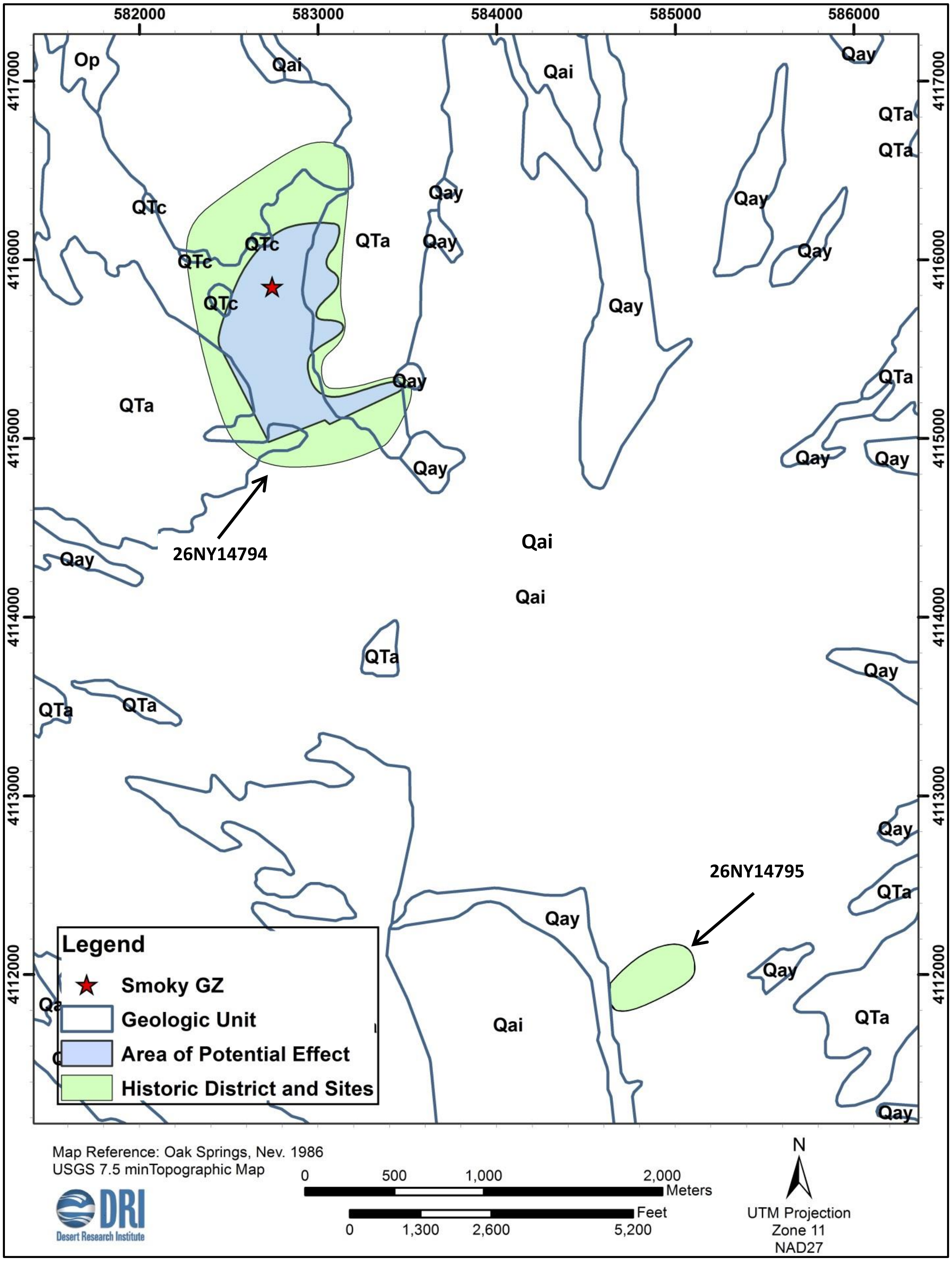

Figure 6. Geologic units in the Smoky project area as described by Slate et al. (1990).

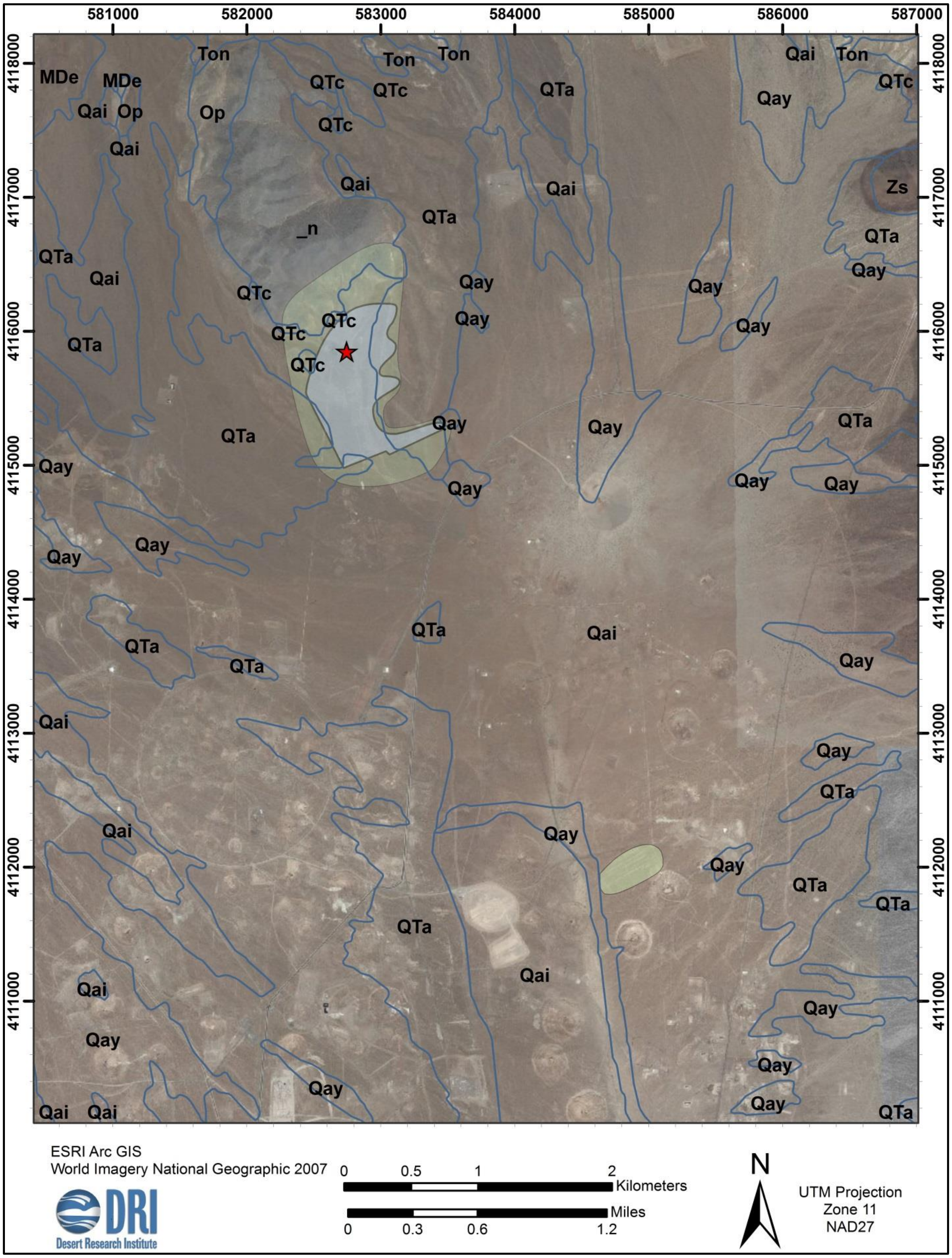

Figure 7. Terrain view with surficial geologic units mapped by Slate et al. (1990).

Qta Old alluvial deposits (middle to early Pleistocene and Pliocene?) - Gravel, sand, and silt; intermixed and interbedded, light brownish gray to light gray. Clasts are angular to subrounded, clasts more than 1 m in diameter are common at and near base of steep slopes. Generally poorly sorted, nonbedded to poorly bedded, and moderately to well cemented with carbonate. Locally consists of moderately well bedded, poorly to moderately well-sorted pebble to cobble gravel in a sand and silt matrix. Surface is eroded and dissected; commonly forms rounded ridges or ballenas. Where preserved, pavement is generally moderately to densely packed and includes tabular fragments cemented by pedogenic carbonate and opaline silica; varnish on pavement clasts is variable but commonly strongly developed. Thickness may be greater than 40 m.

QTc Colluvium (Holocene, Pleistocene, and Pliocene) - Angular to subangular granule- to boulder-sized clasts with variable amounts of sand, silt, and clay as matrix. Generally unsorted and nonbedded to poorly bedded; locally cemented by carbonate. Matrix probably partly of eolian origin. Forms talus deposits and thin mantles of debris along flanks and bases of steep slopes; deposited by rainwash, sheetwash, creep, and mass-wasting processes. Colluvium-mantled surfaces commonly have ribbed or fluted appearance due to gullying and development of stony surface lags. Locally includes bedrock outcrops too small to map separately. Most deposits are probably of Holocene to middle Pleistocene age. In upper Fortymile Canyon, unit includes large blocks of bedrock (greater than 10 m thick) that have slumped into the canyon. Thickness varies, but generally less than 3 m.

VEGETATION

Vegetation at the Smoky test location is sparse as the area has been subjected to construction and nuclear testing activities. Generally, the area is within a *Coleogyne ramosissima-Ephedra nevadensis* shrubland which occurs primarily on the upper piedmont slopes surrounding Yucca Flat. It is dominated by blackbrush (*Coleogyne ramosissima*) with lesser amounts of Nevada jointfir (*Ephedra nevadensis*), white burrobush *(Hymenoclea salsola*), and Anderson’s wolfberry (*Lycium andersonii*) (Ostler et al 2000: 4-31).

FAUNA

Nearly 80 percent of the fauna on the NNSS consists of insects, and of these, most are ants, termites, and beetles (Castetter and Hill 1979; Greger 1994; Medica 1990; O’Farrell and Emery 1976). The more noticeable fauna are coyote (*Canis latrans*), badger (*Taxidea taxus*), kit fox (*Vulpes macrotis*), mule deer (*Odocoileus hemionus*), raven (*Corvus corax*), red-tailed hawk (*Buteo jamaicensis*), chukar (*Alectoris chukar*), quail (*Callipepla gambelii*), jay (*Aphelocoma coerulescens*), golden eagle (*Aquila chrysaetos*), mice (*Perognathus parvus*), kangaroo rats (*Dipodomys microps*, *Dipodomys ordii*), squirrels (*Ammospermophilus leucurus*, *Spermophilus townsendii*, *Spermophilus variegatus*), jackrabbits (*Lepus californicus*), cottontails (*Sylvilagus audubonii*, *Sylvilagus nuttallii*), lizards (*Sceloporus graciousus*, *Sceloporus occidentalis*, *Eumeces skiltonianus*), and snakes (*Chionactis occipitalis*, *Pituophis melanoleucus*, *Crotalus mitchellii*, *Crotalus lutosus*, *Crotalus stephensi*). Other animals known to occur in the region are mountain lion (*Felis concolor*), pronghorn antelope (*Antilocapra americana*), and the occasional bighorn sheep (*Ovis canadensis*).

RESEARCH DESIGN AND METHODS

This cultural resources inventory and historical evaluation of the Smoky atmospheric nuclear tower test area at the NNSS was conducted to comply with Section 106 of the National Historic Preservation Act (NHRP) of 1966, as amended. The project APE consists of 59 hectares (145.8 acres) surrounding this test location. Other studies on the NNSS with an atmospheric testing historic context are bunkers used in atmospheric nuclear tests (Edwards and Johnson 1995; Johnson 2002; Jones 2003, 2004), the Japanese Village (Johnson and Edwards 1996), Camp Desert Rock (Edwards 1997), the Apple-2 Historic District in Yucca Flat (Johnson and Edwards 2000), the Frenchman Flat Historic District (Johnson et al. 2000), and benches for viewing atmospheric nuclear tests (Jones 2005). In the broader context of nuclear testing are studies on underground nuclear test locations in Frenchman Flat (Jones and Drollinger 2001), U12b Tunnel (Jones et al. 2006), the U12e Tunnel (Drollinger et al. 2007), the U12t Tunnel (Drollinger et al. 2009), the U12n Tunnel (Drollinger et al. 2010), and U16a Tunnel (Jones et al. 2012). Historical evaluations of nuclear testing facilities on the NNSS are the Area 2 Equipment Support Yard (Johnson 1994), buildings in the Area 6 Control Point area (Drollinger et al. 2003), the Super Kukla facility (Drollinger et al. 2000; Drollinger and Goldenberg 2004), and the Pluto Control Facility Historic District (Drollinger et al. 2005). The Yucca Lake Historic District (Jones et al. 2005) is a historical evaluation of a high explosive and bomb fuse (detonator) testing area at the NNSS.

Cultural resources determined eligible to the NRHP from the above studies include structures in the Frenchman Flat and Yucca Lake Historic Districts, houses and other structures in the Apple-2 Historic District, the Japanese Village, atmospheric testing bunkers, atmospheric testing viewing benches, buildings at the Area 6 Control Point, the Super Kukla facility, the Pluto Control facility, and the U12b, U12e, U12t, and U12n tunnels. The crater from the Sedan test, a Plowshare nuclear experiment conducted in 1962, is listed on the NRHP. All of these historic properties date to the Cold War era and are representative of some of the nuclear testing activities carried out at the NNSS during this period. This study and historical evaluation focuses on the Smoky atmospheric test location and provides an example of a test conducted from a steel tower.

RESEARCH DESIGN

The research design consisted of archival research for historic documents related to the Smoky test, identification of previous cultural resource investigations in the area, field documentation of the cultural resources within the APE, and a report containing an evaluation of the National Register eligibility and potential effects to historic properties. Archival documents can provide a variety of information including descriptions of the plans for a nuclear test, the site layout, purpose and function of buildings and structures, and historic photographs of the area. This information is then used to develop the historic context of the Smoky test, to guide the fieldwork, and to evaluate its significance for eligibility to the NRHP. For this study, historic information is based on available unclassified records. These include documents and photographs from the NNSA/NFO Nuclear Testing Archive, Las Vegas; the NNSA/NFO Technical Library, North Las Vegas; the NNSA/NFO Remote Sensing Laboratory, Las Vegas; the Archives and Records Center, Mercury, Nevada; and the Defense Threat Reduction

Information Analysis Center (DTRIAC), Kirtland Air Force Base, New Mexico. All photographs and drawings in this report have been approved for public release.

Following the archival research was the effort to identify previous cultural resource investigations. Under contractual agreement with NNSA/NFO, DRI maintains records of cultural resources inventories, historical evaluations, and archaeological site forms and maps for the NNSS. Previous cultural resource investigations within 1.6 km (1 mile) of the project area are nine projects reported in one technical report and eight Class III cultural resources inventories (Table 2, Figure 8). Three archaeological sites were identified during these studies, two lithic scatters and historic debris. None of these are eligible to the NRHP. However, Sedan, a crater from a 1962 Plowshare test, is 1.2 km (.7 mi) southeast of the Smoky project area. This crater was listed in the NRHP on April 1, 1994.

After the background research on the history and cultural resources was completed, the focus shifted to understanding the physical setting for the project and documenting the cultural resources in the APE. In the case of the Smoky test, the location is isolated, fenced, and has restricted access. Therefore, it was not possible to preview the area prior to the fieldwork. However, the condition of the post-shot ground zero and environs was known from an entry into the location by DRI archaeologists in the mid-1990s. During this visit, the archaeologists observed an abundance of metal tower fragments and a number of associated structures. In the test plans, various structures were identified including the tower (ground zero) the supporting sets of stanchions, an elevator winch, instrument stations, a set of French personnel shelters, and a set of German personnel shelters. In addition, research found military trenches for troop observation of this test were constructed 4.3 km (2.7 mi) southeast of ground zero. Following the fieldwork, a cultural resources inventory and historical evaluation report was prepared that presents the results of the archival research and field documentation, evaluations of National Register eligibility, assessments of potential effects to historic properties, and an appendix with relevant IMACS and Nevada SHPO ARA forms.

METHODS

An inventory was conducted of the project's APE with the exception of an 8 hectare (19.8 acre) area within a high contamination area (see Figure 5). No entry was made into high contamination areas. The field work was conducted by DRI archaeologists Colleen Beck, Justin DeMaio, Barbara Holz, and Robert Jones in eight days during February, March, April, and August, 2012. Because most of the project area is within a contaminated area (CA), radiological safety procedures were observed at all times. For the cultural resources inventory, a clean line was established approximately 450 m (1,476 ft) southwest of ground zero at the intersection of the powerline access road and a northwest trending fence. Entry and exit into and out of the CA was supervised by radiological control personnel who provided escorts inside the CA and personnel at the clean line to check both equipment and personnel upon departure. Personnel entering the CA wore Tyvek suits and safety boots with protective covers, cotton gloves, and two layers of Nitrile gloves (Figure 9). An air monitor was worn along with a dosimeter. The intent was to survey the project area with archaeologists walking pedestrian transects at roughly 30 m intervals. However, the survey strategy was modified, when necessary, to accommodate factors involved in conducting work in a CA and the 30 m interval was not strictly adhered to.

Conversely, immediately surrounding the Smoky ground zero is a dense concentration of artifacts, primarily tower components and lead bricks, which was documented using one to two meter intervals. The number of days and hours per day in the project area was limited and all work had to be conducted within the time constraints. These restrictions affected the quantity and quality of data that could be recorded as well as the level of photographic documentation. As a cautionary measure, no cultural resources were handled during the survey nor were artifacts collected for subsequent analysis. Digital photographs were taken of the general project area and buildings, structures, features, and artifacts were described, approximately measured, and photographed. Coordinates were recorded using handheld GPS units.

Table 2. Previous Surveys and Recorded Sites within 1.6 km of the Smoky Project Area.

Report #	Author	Site #	Site Type	NRHP Eligibility
SR070182-6	Clerico (1982)	26NY3121	Lithic Scatter (sparse)	Not Eligible
SR070182-7	Clerico (1982	26NY3121	Lithic Scatter (sparse)	Not Eligible
SR113082-1	Pippin (1982)	None	N/A	N/A
SR012583-1	Reno (1983)	26NY3121	Lithic Scatter (sparse)	N/A
SR030992-1	Johnson (1992)	26NY7992	Historic Debris	Not Eligible
SR041092-1	Holz and Gilbert (1992)	None	N/A	N/A
SR110992-1	Holz (1992)	None	N/A	N/A
SR070903-1	Jones (2003)	None	N/A	N/A
TR 35	Reno and Pippin (1985)	26NY3122	Isolate Biface	Not Eligible

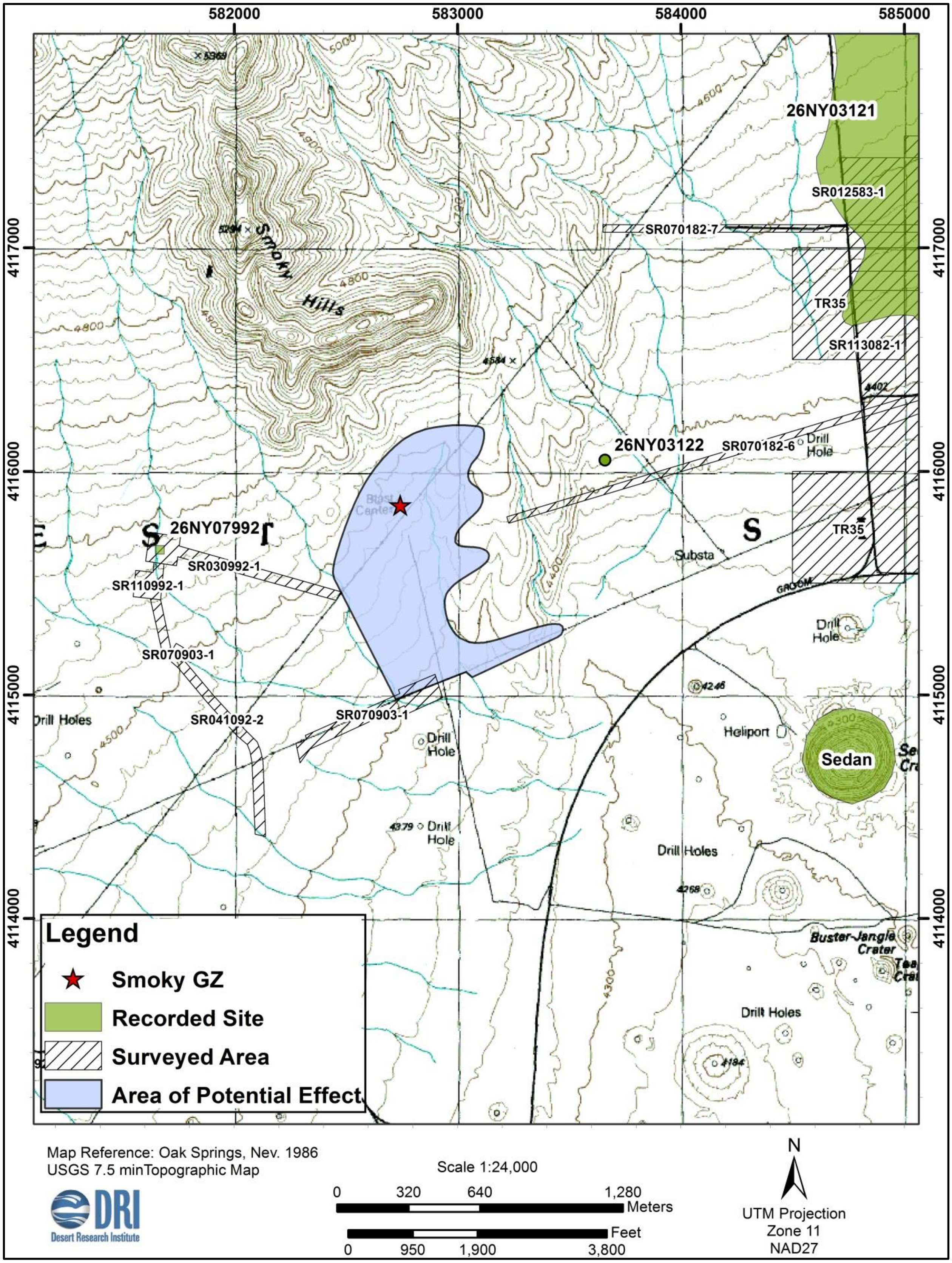

Figure 8. Previously recorded sites and surveyed areas within 1.6 km of the Smoky area of potential effect.

Figure 9. Personal protective equipment worn within the CA, view north (2012).

HISTORIC CONTEXT

The Smoky atmospheric test is associated with the United States nuclear weapons testing program at the NNSS during the Cold War with the former Soviet Union. A result of this confrontation was an ever-escalating arms race for nuclear weapon superiority (Anders 1978:4; Loeber 2002:80; Ogle 1985:20). This led to numerous nuclear detonations worldwide in the atmosphere, outer space, underwater, and underground. Below is a brief history of U.S. nuclear testing, a description of the Smoky test, associated projects and experiments, and research questions that guided this research.

NUCLEAR TESTING

In the early days of nuclear testing, there was an urgent need to understand the science and engineering of these powerful new weapons and their effects. Shortly after World War II, the AEC, now the U.S. DOE, was established when President Harry Truman signed the Atomic Energy Act of 1946. The purpose of the act was to address government control of fissionable material, nuclear experiments for military applications, and regulations pertaining to the release of scientific and other related data. The function of the AEC was to maintain civilian government control of the research, development, and production of atomic weapons for the military (Anders 1978:2). The DOD, with the establishment of the AFSWP in 1947, had a continuing role post-World War II in the testing of nuclear weapons at the Pacific Proving Grounds and later at the NNSS (DTRA 2002). General L.R. Groves, who was instrumental in developing the first nuclear weapon during the Manhattan Project and in keeping the military active in the nuclear weapons industry after the war, was appointed chief of AFSWP in early 1947 (DTRA 2002:35). The primary mission was to train military personnel in the assembly, storage, and firing of the atomic weapon, tasks previously conducted primarily by civilian scientists.

ATMOSPHERIC NUCLEAR TESTING

During the late 1940s, a search was conducted to establish a nuclear test site in the continental United States, remote from the populace and near the research laboratories. The main reasons for this were security, shorter travel times, and economic costs in the transportation of people and equipment (Lay 1950; Ogle 1985:44; Tlachac 1991a, 1991b). At the time, nuclear testing was conducted at the Pacific Proving Grounds in the Pacific Ocean and was expensive in both cost and time. Security at the Pacific locale became a major concern due to the situation developing in Korea (DTRA 2002:77). Four places in the United States were seriously considered for a continental testing ground: Camp Lejeune in North Carolina, Dugway Proving Ground in Utah, White Sands Proving Ground in New Mexico, and the Las Vegas Bombing and Gunnery Range in southern Nevada (Lay 1950). The ideal location, in addition to the attributes described above, was to have favorable and predictable weather and terrain conditions to be able to test year round, be under federal control, and have an infrastructure already in place (Lay 1950; Tlachac 1991).

A portion of the bombing and gunnery range in southern Nevada was the place chosen that best met the conditions for the continental nuclear test site. This land was withdrawn for use as the Nevada Proving Grounds which became the Nevada Test Site and eventually the NNSS. The first land withdrawal by the AEC establishing the official nuclear weapons testing ground in the continental United States was February 12, 1952 under Public Land Order 805. Additional

land parcels were obtained under public orders and memorandum of agreements. Today the NNSS encompasses an area of approximately 1,360 square miles (3,522 sq km), and spans approximately 55 miles (89 km) north-south and 30 miles (50 km) east-west.

Nuclear weapons research also was conducted at the Los Alamos Scientific Laboratory (now LANL) New Mexico, established in 1943 as part of the Manhattan Engineer District. Development and production of the weapons took place at Sandia Laboratory (now SNL), New Mexico, established in 1948; the Y-12 Plant in Oak Ridge, Tennessee; at Hanford, Washington; and the Rock Island Arsenal in Illinois (Anders 1978:3; Brady et al.1989:18-19; Stapp 1997). The first atmospheric nuclear test on the NNSS was in Frenchman Flat, Area 5, with test Able of Operation Ranger on January 27, 1951 (Ogle 1985:43-44; Titus 1986:58). Operation Ranger was a series of atmospheric nuclear weapons tests conducted by the AEC at the NNSS. It consisted of five nuclear detonations, all of which were airdrops above Kay Blockhouse, which has been determined eligible to the NRHP (Jones 2003). Kay Blockhouse is a subterranean blockhouse (bunker) built as an instrument station in 1951 for Operation Ranger. The operation also included one non-nuclear high-explosive test detonated two days before the first nuclear event. Operation Ranger lasted from January 25 through February 6, 1951, and involved approximately 770 DOD participants. The series was intended to provide data for use in determining design criteria for nuclear devices scheduled for detonation during Operation Greenhouse, to be conducted at the Pacific Proving Ground from April 7 to May 24, 1951 (Maag et al. 1982).

Following the first nuclear detonation by the former Soviet Union in 1949 (Anders 1978:4; Ogle 1985:20), increased efforts for research and production were implemented in the United States. A second nuclear weapons research laboratory was established in 1952 at Livermore, California (Brady et al.1989:18). The Livermore laboratory was initially designated as the University of California Radiation Laboratory, a branch of the Berkeley Radiation Laboratory, and then in 1958 it became the Lawrence Radiation Laboratory. In 1971, it separated from the Berkeley laboratory to become a national laboratory, and in 1982, it became LLNL (DOE 1997:203). Other facilities added to the nuclear weapons industry in the 1950s included manufacturing plants at Rocky Flats near Golden, Colorado; the Kansas City Plant in Missouri; the Burlington Army Ordnance Plant in Iowa; the Pinellas Plant in Largo, Florida; Mound Laboratory in Miamisburg, Ohio; and the Pantex Plant near Amarillo, Texas (Anders 1978:4; DOE 1997:27).

In the 1950s, the nuclear devices were initially dropped from airplanes for the atmospheric nuclear tests on the NNSS, but due to efforts for greater monitoring and a general lack of control on air drops, the devices were placed near the ground, on top of towers, and eventually elevated by balloons to the desired height. At this time in the Pacific Proving Ground, high altitude tests of large yield were being performed, mostly by balloon, a few on rockets into outer space. Other tests were on barges and underwater (Ogle 1985:49-50). Main objectives of the testing were for monitoring, measuring, perfecting techniques, and technological improvements of the nuclear weapons (Ogle 1985:84-85). Other objectives included physical effects (DTRA 2002:106). Some of the earliest experiments determined the physical effects from a nuclear detonation on naval ships, while later experiments evaluated physical effects on airplanes, tanks, jeeps, automobiles, clothing, docks, and different types of houses, underground structures, and radio and radar transmissions. At the NNSS, various structure and building designs were included for civil defense, such as underground shelters, domed subterranean structures, concrete and brick buildings, residential houses, a metal bridge, and a bank vault. In

some cases, U.S. Army personnel participated in the tests in preparation for nuclear warfare. Camp Desert Rock, located at the south edge of the NNSS, was created to house military and other personnel involved in the nuclear tests as participants or as observers (DTRA 2002:80, 85; Edwards 1997:1).

In 1955, the AEC began safety tests to ensure that no nuclear reaction would occur if the high explosive components of the device were accidentally detonated during storage or transport and determine what contamination might result from the spread of nuclear materials from such an accident (Harris et al. 1981b:34). Four tests were conducted in Area 11 under Project 56 and one outside the boundary of the NNSS under Project 57. Operations Roller Coaster, Double Tracks, and Clean Slate 1 was a series of plutonium dispersal tests conducted on the Tonopah Test and Training Range.

In 1957, Operation Plumbbob was the sixth series of atmospheric nuclear weapons tests conducted within the continental United States. It consisted of 24 nuclear detonations, of which Smoky was number 19, and six safety tests. The Plumbbob series lasted from April 24 to October 7, 1957, and involved about 18,000 DOD personnel (Harris et al. 1981b:1). The activity with the largest DOD participation during Plumbbob was Exercise Desert Rock VII and VIII. Exercise Desert Rock VII and VIII included training programs, tactical maneuvers, and technical service projects. Training programs generally included lectures and briefings on the effects of nuclear weapons, observation of a nuclear detonation, and a subsequent visit to a display of military equipment exposed to the detonation. At shots Hood, Smoky, and Galileo, maneuvers were conducted to develop tactics applicable to the nuclear battlefield. At Hood, the Marine Corps conducted a maneuver involving the use of a helicopter airlift and tactical air support. At Smoky, Army troops conducted an airlift assault, and at shot Galileo, Army troops were tested to determine their psychological reactions to witnessing a nuclear detonation. Technical service projects were designed to test equipment and techniques.

The United States and the former Soviet Union ceased nuclear testing in 1958 by self-imposed moratoriums at the urging of internal and external forces (Ogle 1985:30-31), but by 1961 both superpowers were once again conducting nuclear tests. Except for a few surface and near-surface tests, most of the tests were placed underground. The last atmospheric nuclear test, Little Feller I, was conducted on July 17, 1962 near Buckboard Mesa in Area 18. After ratification of the Limited Test Ban Treaty by the United States, the former Soviet Union, and Great Britain in 1963, all nuclear tests were underground (Friesen 1995:6). According to the treaty, no tests could be conducted in the atmosphere, outer space, or underwater. Furthermore, certain safeguards for the United States were established in order for the U.S. Senate to ratify the treaty (DTRA 2002:246). These safeguards were an intensive underground testing program, maintenance of the weapons laboratories, the ability to resume atmospheric testing on short notice, and improvements in verifying compliance to the treaty. In 1974, the United States and the former Soviet Union agreed to the Threshold Test Ban Treaty and, in 1976, to the Peaceful Nuclear Explosions Treaty in order to restrict nuclear test explosions to a defined test site and to yields no greater than 150 kilotons. A second self-imposed moratorium on nuclear testing by the United States was established in 1992, and in 1996, the United States signed the Comprehensive Test Ban Treaty banning all nuclear tests. This latter treaty, however, has yet to be ratified by the U.S. Senate.

UNDERGROUND NUCLEAR TESTING

The concept of the underground test was not acted upon until the late 1950s when containment of the nuclear explosions became a major issue (Carothers 1995:16, 20; Johnson et al. 1959:2; Malik et al 1981:12; Byron Ristvet, personal communication 2006). Radioactive fallout was a safety and health concern for both the workers doing the tests and for the public at large. The result was to go underground with the nuclear testing. Initially, this posed a new engineering challenge and learning experience and not all tests were able to be contained right away. The first successfully contained underground nuclear test was the Rainier test in U12b tunnel in Area 12 (Jones et al. 2006). After a number of underground nuclear tests had been completed, it was determined that radioactive material from nuclear tests could be satisfactorily contained with proper depths of burial, stemming of the drill hole or tunnel, blocking seeps around cables and pipes, and understanding the surrounding geology for possible cracks or other weaknesses (Malik et al 1981:12-15).

Most of the underground nuclear tests at the NNSS have been for either weapons development or for weapons effects (DOE/NV 2000). A few tests had other purposes, such as safety experiments, industrial engineering for the Plowshare program, and seismic monitoring. Sedan, Operation Storax, was a Plowshare excavation experiment that produced a 390 m (1,280 ft) diameter crater that was 98 m (320 ft) deep. Sedan is listed on the NRHP. Weapons development tests evaluated the performance of the nuclear device itself and were usually placed in vertical shafts; whereas, weapons effects tests evaluated the effects on critical components of missiles and warheads, and sometimes entire systems, and were usually conducted in horizontal tunnels deep underground (Brady et al. 1989:2; Wolff 1984). Generally, two to four years went into the planning, preparation, construction, and post test analyses of a single underground nuclear weapons effects test.

SUMMARY

A total of 928 atmospheric and underground nuclear tests have been conducted at the NNSS, with 120 performed in the 1950s and 808 after 1961 (DOE/NV 2000; Friesen 1995:6, 10). Atmospheric nuclear tests number 100 with most of these conducted on Frenchman Flat or Yucca Flat and others in the upper Fortymile Canyon area on or near Buckboard Mesa. Most of the 828 underground nuclear tests were either in vertical shafts on Yucca Flat, Frenchman Flat, and Pahute Mesa or in horizontal tunnels mined into the sides of Pahute, Aqueduct, and Rainier mesas. Other underground (crater) nuclear tests were conducted on Buckboard Mesa.

SMOKY

Smoky, T-2c, was a 44 kt test detonated at 5:30 am on August 31, 1957 in Area 8 of the NNSS (DOE/NV 2000:8-9) at UTM coordinate 582744 E, 4115845 N (Figure 10). Smoky was a weapons related test of the Plumbbob series (number 19) and part of the DOD Exercise Desert Rock VII and VIII. Smoky was originally scheduled for August 19, 1957 but was not ready until August 28. It was postponed twice due to the effects from preceding nuclear tests and twice due to weather conditions. On July 15, 1956, the Diablo atmospheric nuclear test produced fallout that reached the Smoky ground zero. From July 22 to July 29, 1957, Reynolds Electrical and Engineering Company personnel decontaminated the area by bulldozing contaminated soil away from the Smoky tower (Maag and Ponton 1981:42). On August 18, 1957, the Shasta atmospheric


Figure 10. Smoky fireball, view north (1957: photograph 3198-5 on file at the NNSA/NFO, Nuclear Testing Archive, Las Vegas, Nevada).

nuclear test was fired and contamination postponed the Smoky test scheduled for August 19 (Harris et al. 1981a:17). On the morning of August 31, the test was delayed 30 minutes until 5:30 am to collect additional weather data.

The Smoky test area is relatively flat area (Figure 11) with undulating terrain to the east and west (Figure 12) and the Smoky Hills 500 m (1,640 ft) to the north (Figure 13). The 213 m tower was on the south end of a flat area that was the center fo r testing activities. The sixteen permanent guy cables extended at 45^0 angles from the four sides (4 per side) of the tower. These were site at various distances up to 213 from the tower. The five experiment cables were fanned out from the tower and up to 1,158.2 m (3,800 ft) to the south. Experiment bundles were hung from the cables. Just north of the tower were the two man-made hills that now dominate the landscape. The German underground personnel shelters aligned north-south along the blast line and 200 m (656 ft) to 1,265 m (4,150 ft) south of the tower along the slightly south sloping terrain. The German shelters entrances were set flush with the surface and just visible on the surface. The French underground personnel shelters were at the 300 m (984 ft) from the tower an perpendicular to the German shelters. The French shelters had concrete vent stacks that extended 1.2 to 1.8 m (4 to 6 ft) above the surface. The French and German shelters are listed as instrument stations because various instruments were placed within the structures for the test. Other instrument stations, such as pressure gauges, were both above and below the surface. Before the test, 51 jeeps and 2 M-48 tanks were places at various locations on the flat surfaces and in drainages for ground shock tests. Traps were placed on the surface to catch blast-produced missiles (i.e., rocks, wood, etc.) from the blast. A two track road crossed the area near the tower from west to east.

The southern portion of the project area is the trench area 4.2 km south of the Smoky test location. This is a relatively flat sandy area that slopes to the southwest. It consists of seven trenches that extend southwest to northeast. Four are 427 m (1,400 ft) in length and three trenches are less than 50 m in length and appear to have been dug by machine. A two track road crossed the west end of the trenches.

SMOKY TOWER

The Smoky tower was a 213.4 m (700 ft) tall, 200 ton, four sided metal frame structure with an elevator on the south side and a cab on top. It was 6.1 x 6.1 m (20 x 20 ft) to the center of the four legs (Figure 14 and 15). Footings for each tower leg were 4.6 x 4.6 x 0.9 m (15 x 15 x 3 ft) concrete pads buried 2.2 m (7 ft 3 inches) below the surface. On top of the pad was a 1.2 x 1.2 x 1.3 m (4 x 4 x 4 ft 3 inch) concrete pedestal which supports the 15.2 cm (6 inch) thick base plate for the 22.9 cm (9 inch) diameter steel legs (Figure 16). The round legs extended to the 61 m (200 ft) level and then 22.9 x 22.9 cm box beams legs that were 2.9 cm (1 1/8 inch) thick were used to the 76.2 m (250 ft) level. From 76.2 m to the top of the tower 22.9 x 22.9 box beams that were 2.2 cm thick (7/8 inch) were used. The tower was constructed in 7.6 m (25 ft) sections consisting of the tower leg, struts, and tension rods (diagonal bracing). The struts were 11.7 cm (4 5/8 inch) box beams that connected horizontally to the legs forming a square. The struts were secured to attachment plates welded to the tower legs with 1.9 cm (3/4 inch) bolts. The tension rods were approximately 4.1 m (13 ft 6 inch) round bars with clevis attachments. The bracing was in an X pattern on all four sides of the sections. Round pins, 11.4 cm (4 1/2 inches) in

Figure 11. Overview of Smoky test area (arrow at ground zero), view north (2012).

Figure 12. View of Smoky test area from near ground zero, view southeast (2012).


Figure 13. Overview of Smoky test area and Smoky Hills (arrow at ground zero), view north (2012).

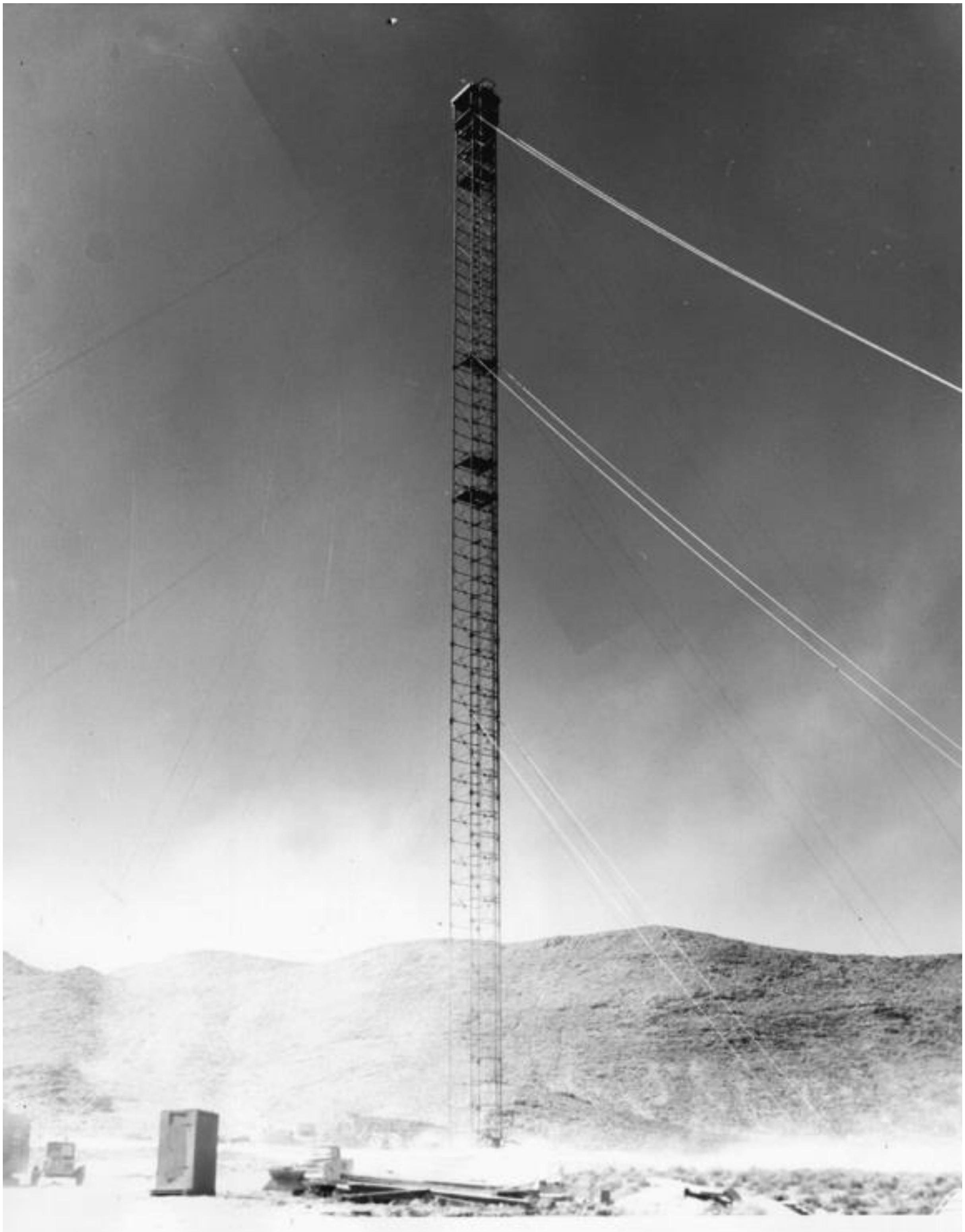

Figure 14. Smoky tower, view north (1957, photograph 3197-11 on file at the NNSA/NFO, Nuclear Testing Archive, Las Vegas, Nevada).

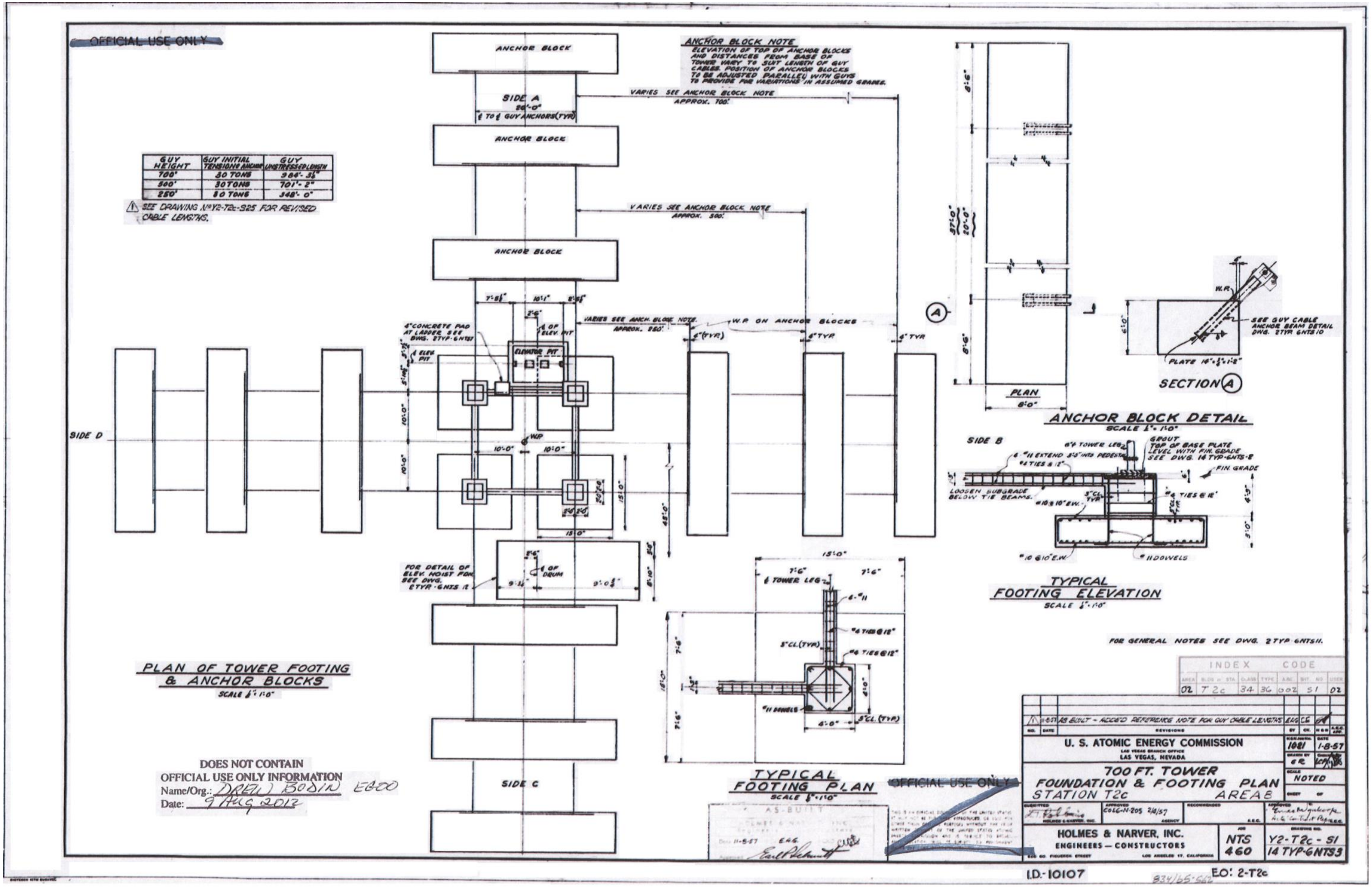

Figure 15. Smoky 700 ft tower foundation and footing plan.

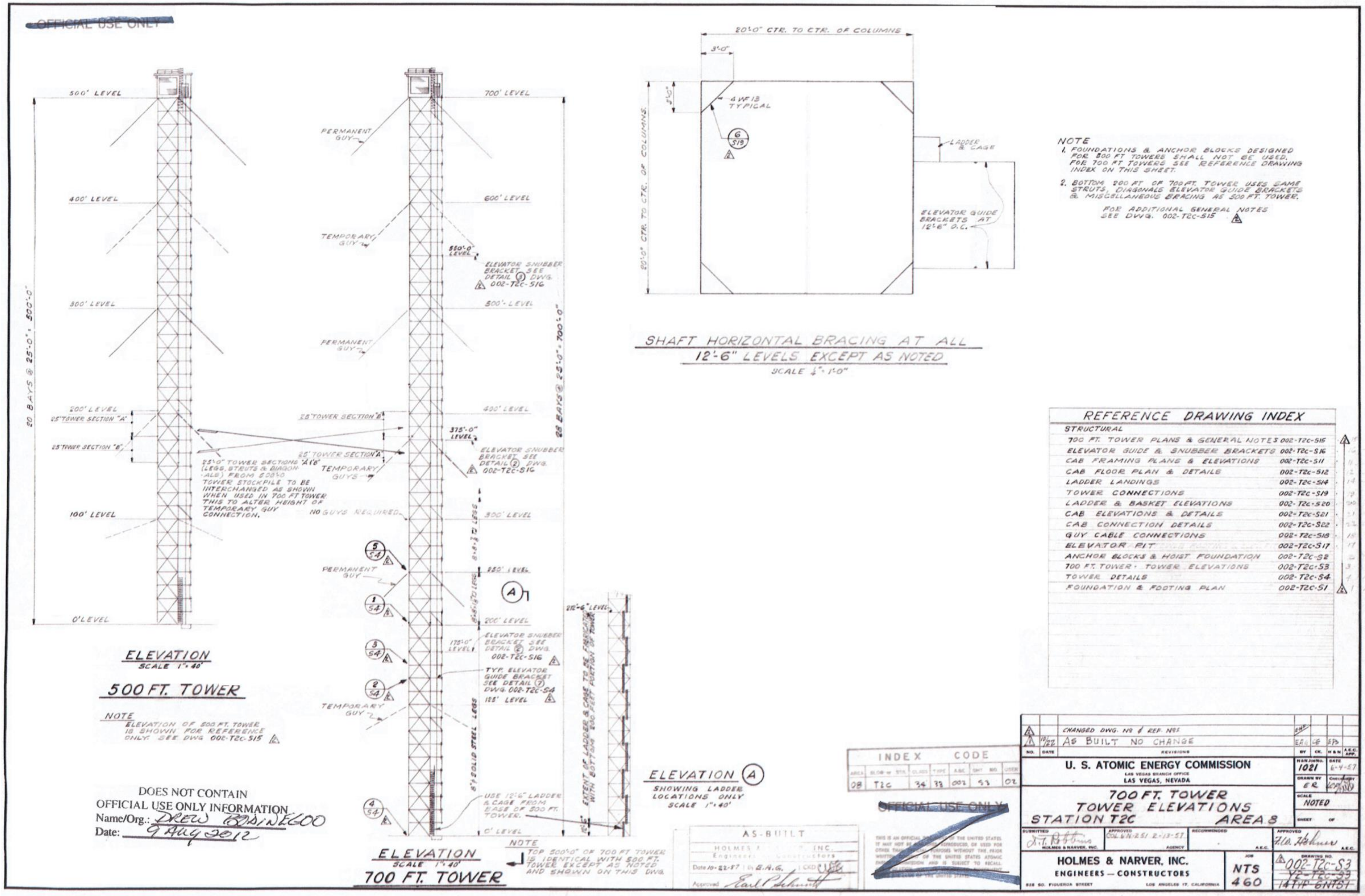

Figure 16. Smoky 700 ft tower elevations.

diameter, secured the clevis to attachment plates on the struts (Figure 17). A ladder extended from the surface to the cab along the southeast corner of the tower (Figure 16). Platforms were constructed at the 122 m (400 ft),129.5 m (425 ft), 152.4 m (500 ft), 199 m (653 ft), 205.7 m (675 ft), and 211.2 m (693 ft) levels (Figure 18). The platform's decking (metal grating) was Type SW 100A Superweld grating manufactured by Supergate Open Steel Flooring Co. of Maywood, California. The grating was oriented in various directions and welded to supporting beams. The supporting beams were bolted to the tower struts with 1.9 cm bolts. On top of the tower was a 6.1 x 6.1 x 6.6 m (20 x 20 x 21 ft 9 inch) cab with three doors (Figures 19-21). The cab was sheathed with corrugated fiberglass and the top was 18 gauge Fenestra Holorib Decking (steel and composite decking) secured with #10 self-tapping screws. One door was a 5.6 x 6.2 m (18 ft 4 inch x 20 ft 5 inch) roll up, one was a 2.8 m (9 ft 11/2 inch) raisable with pilot door, and one was a 0.8 m (2 ft 5 1/2 inch) hinged door. The steel roll up door was made of interlocking 18 gauge slats. It was electrically operated with a 440 volt, 3 phase, electric motor with upper and lower limit switches. The elevator was adjacent to the raisable door. A ladder provided access to the top of the cab that was enclosed with a handrail.

The tower was supported by permanent guy cables oriented in four directions (Figure 22). Two cables were attached to the each side of the tower at the 76.2 m, 152.4 m, and 213.4 m levels (Figure 16). The cable ends were fitted with a clevis to be connected to attachment plates on the tower and closed bridge strand sockets at the anchor block (Figure 17). Each clevis was secured to the attachment plate on the tower with a 11.4 cm (4 1/2 inch) diameter pin. The cables were 6.4 cm (2 1/8 inch) galvanized bridge strand prestressed cables. Anchor blocks secured the stanchions to the surface. The anchor blocks were 11.3 x 2.4 x 1.8 m (37 x 8 x 6 ft) and oriented with the long edge to the tower (Figure 22). Two guy cable anchor beams were set in each concrete anchor at 2.6 m (8 1/2 ft) from each end. The cable to ground angle was 45 degrees, thus the 76.2 m tower level cables were attached to an anchor block at approximately 76.2 m from the tower base, the 152.4 m tower level cables were attached to an anchor block at 152.4 m from the tower base, and the 213.4 tower level cables were attached to an anchor block at 213.4 m from the tower base (all distances for the blocks varied 1 to 1.5 m) (Figure 22). The 76.2 m level cables were 106 m (348 ft), the 152.4 m level cables were 213.7 m (701 ft), and the 213.4 m level cables were 300 m (984 ft) in length (all unstressed lengths). Initial tension at the anchor blocks was 30 tons for all of the cables. Temporary guy cables were attached to the tower at the 38.1 m (125 ft), 114.3 m (375 ft), and 182.9 m (600 ft) levels. It is not known at this time when or if these cables were removed before the test. In addition, five cable systems were secured to the tower for the attachment of experiments (Figure 23). Cable systems 1, 2, 4, and 5 were 701 m (2,300 ft) in length and cable system 3 was 1,158.2 m in length. In Harris et al. (1981a:65, Figure 3-6), a drawing shows a sixth line, specimen guy wire, extended 2,286 m (7,500 ft) from the tower but it is not shown on any engineering drawing for the tower. Cable system 1, 2, 4, and 5 were 1.6 cm (5/8 inch) diameter; cable system 3 was 2.2 cm (7/8 inch) in diameter; and the specimen guy cable was 0.3 cm (1/8 inch) in diameter. All cables were Bethlehem purple strand 6 x 19 class wire rope and attached to the 213.4 m level of the tower. Systems 1, 2, 4, and 5 were anchored with 1.8 x 1.2 x 0.7 m (6 ft x 4ft x 2 ft 6 inch) concrete blocks and a 1.6 m (5 ft 8 inch) metal beam for the cable attachment. System 3 was anchored with a 3.4 x 1.8 x 0.6 m (11 x 6 x 2 ft) concrete block and a 0.7 m (2 ft 8 inch) metal beam for the cable attachment. The cables were threaded through 2.5 cm (1 inch) or 1.9 cm standard solid thimbles and secured with three or four 1.6 or 2.2 cm U-bolt clamps.

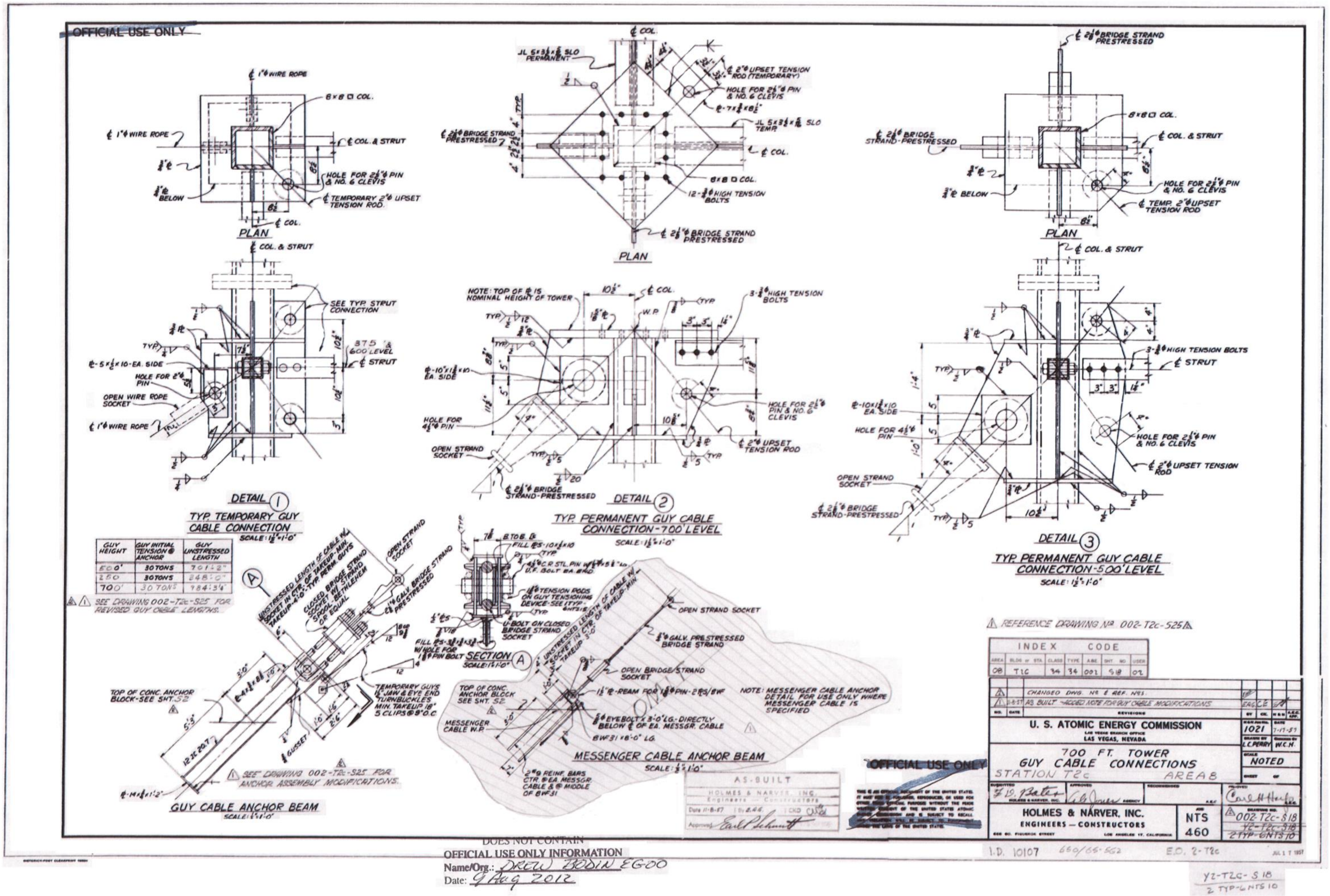

Figure 17. Smoky 700 ft tower guy cable connections.

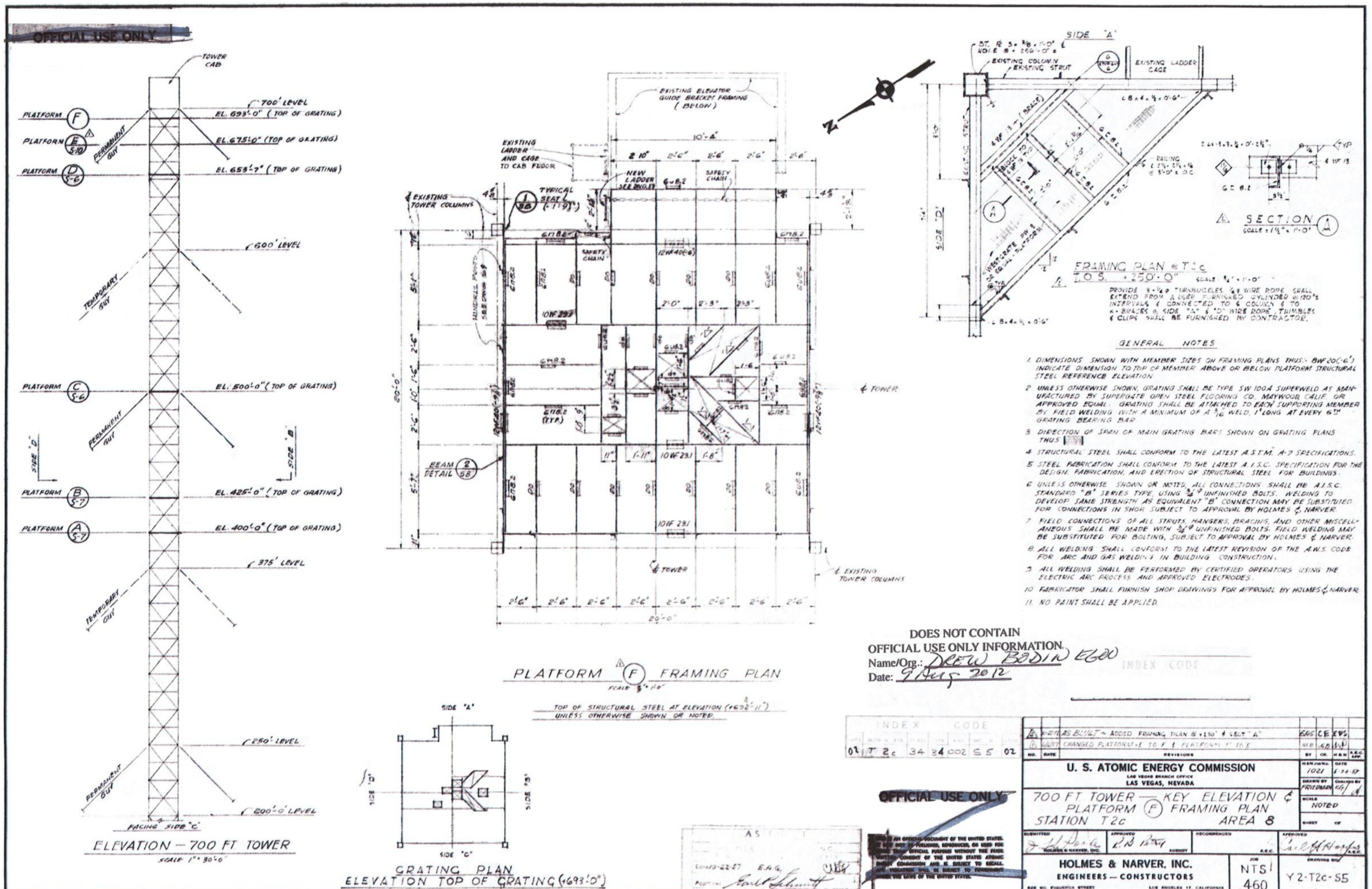

Figure 18. Smoky 700 ft tower key elevation and platform framing plan.

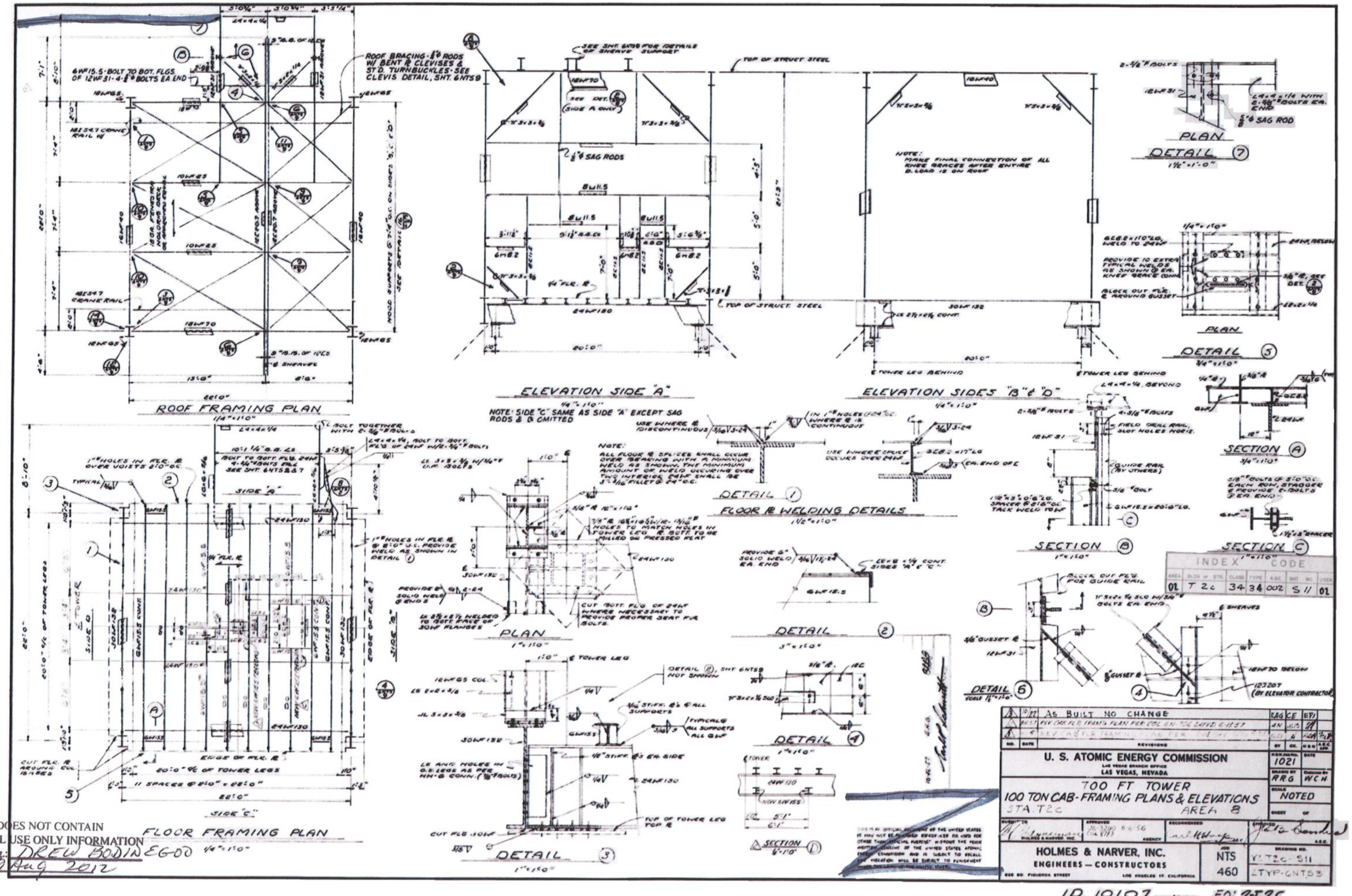

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Figure 19. Smoky 700 ft tower, 100 ton cab framing plans and elevations.

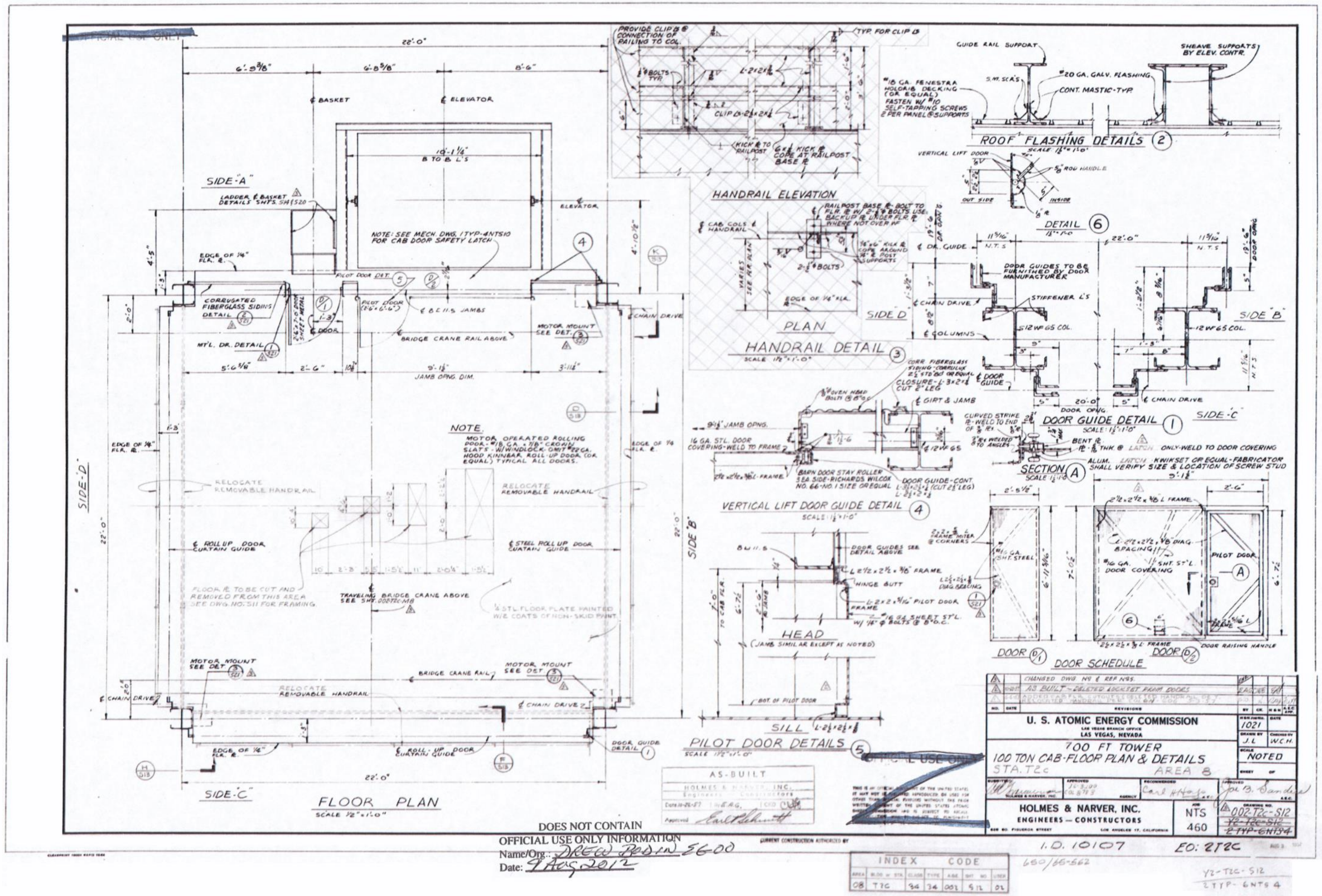


Figure 20. Smoky 700 ft tower 100 ton cab floor plan and details.

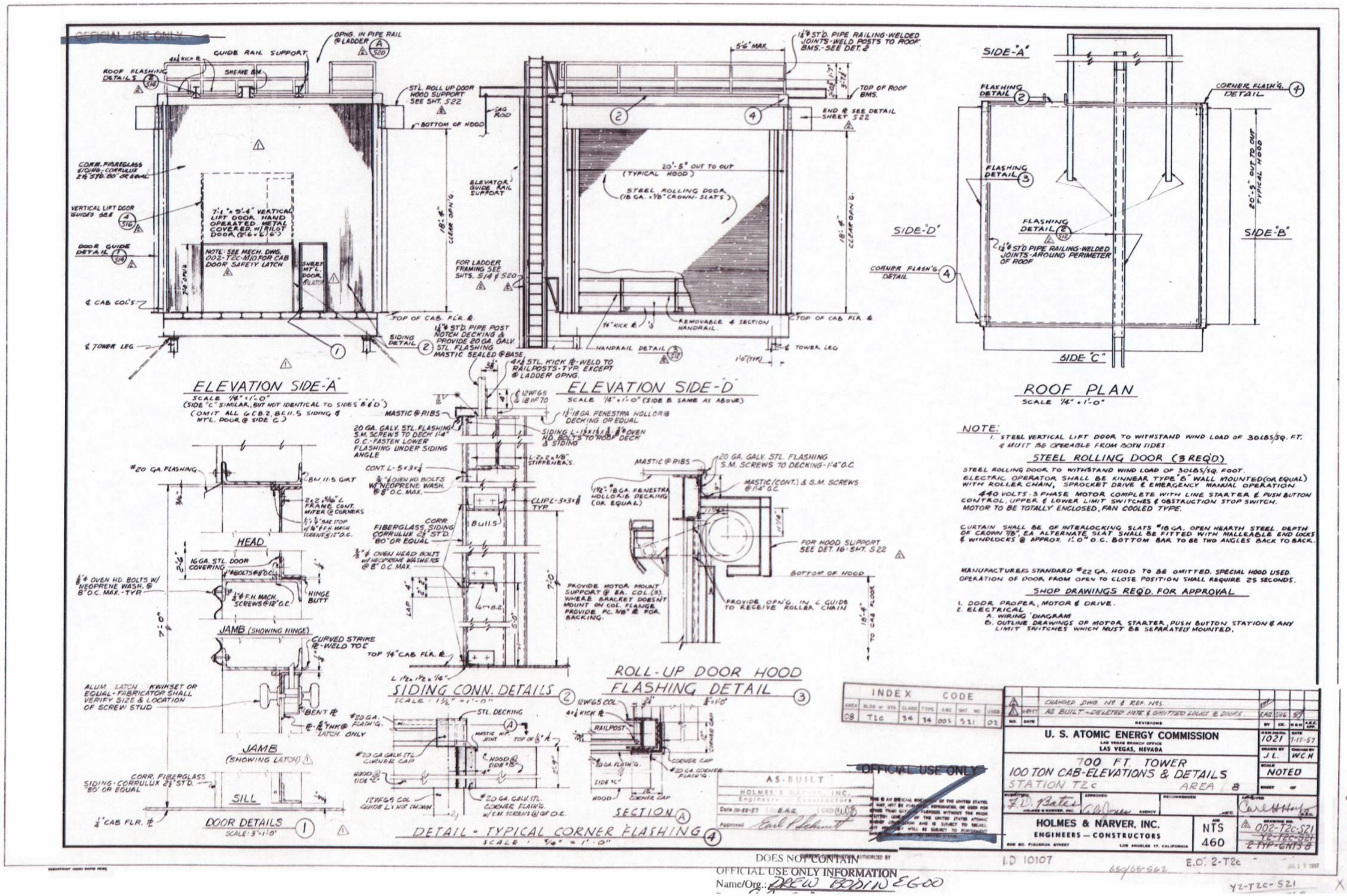


Figure 21. Smoky 700 ft tower 100 ton cab elevations and details.

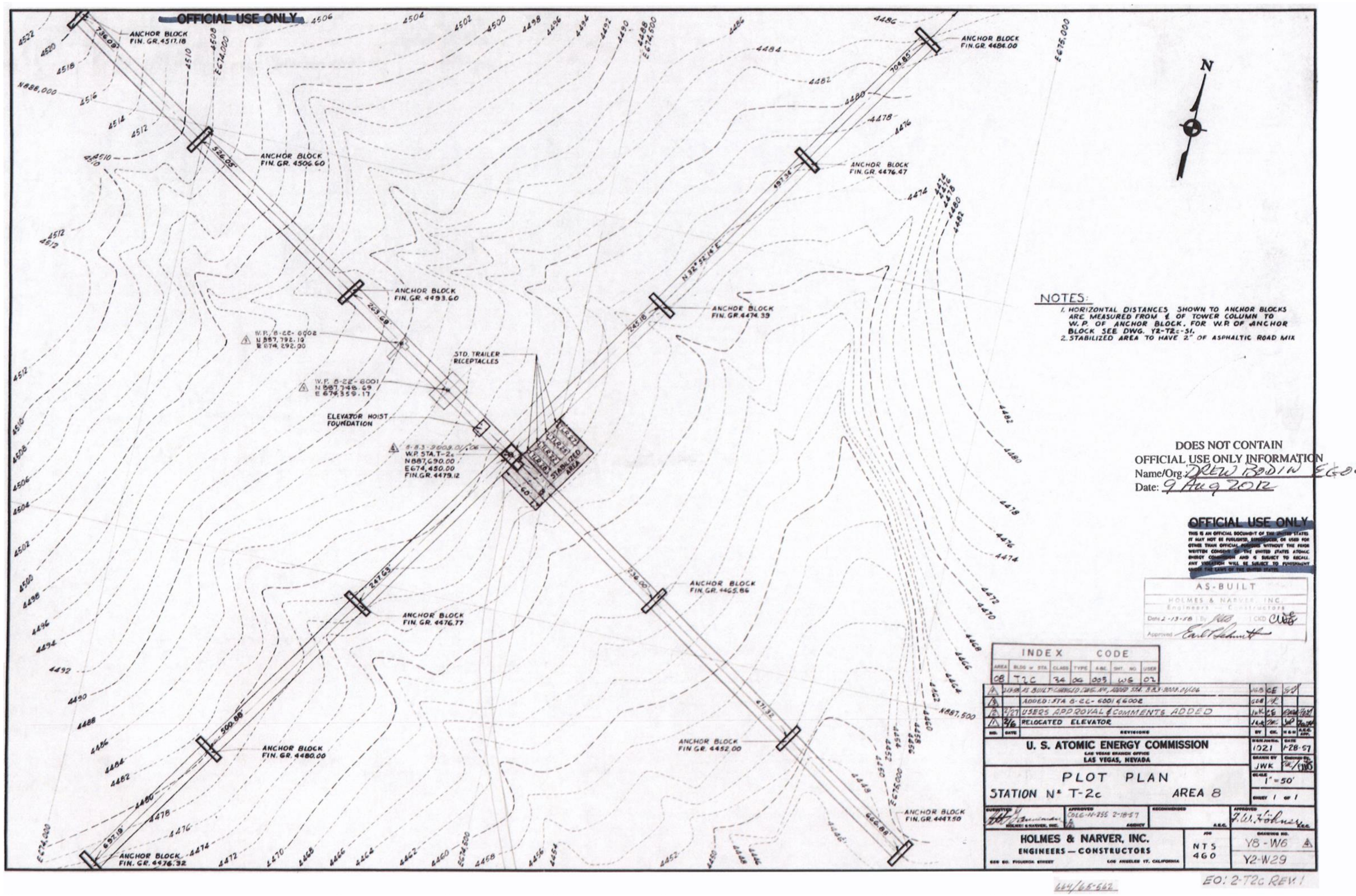


Figure 22. Smoky 700 ft tower plot plan.

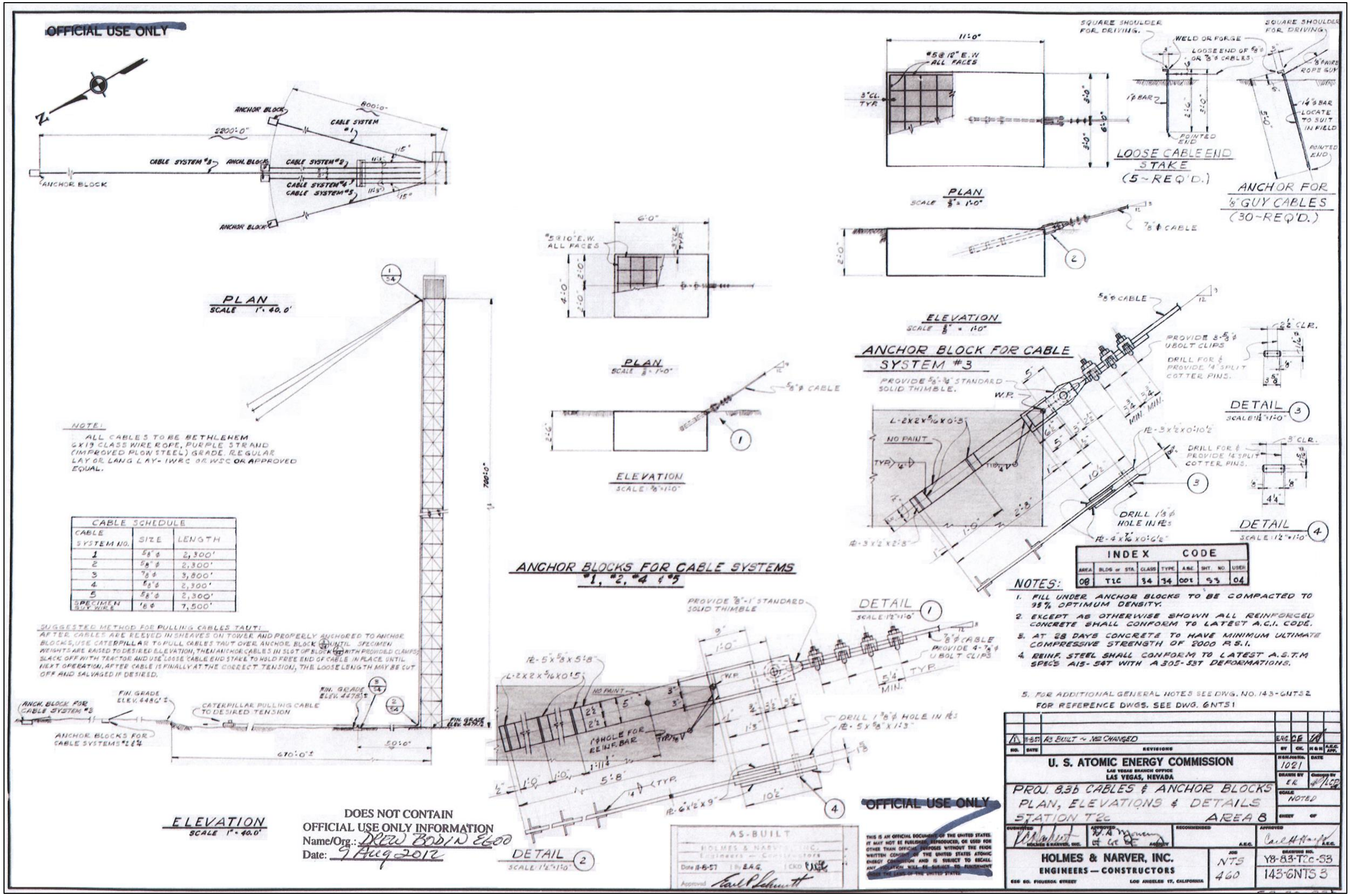


Figure 23. Smoky 700 ft tower cables and anchor blocks for instrumentation cable system, plans, elevations, and details.

The elevator assembly, attached to the south side of the tower, consisted of the elevator pit, hoist system, and cage. At the base of the elevator assembly was the 3.6 m (11 ft 9 inch) long, 2.7 m (9 ft 1/2 inch) wide, 1.5 m (4 ft 11 inch) deep concrete lined elevator pit. The walls of the pit were 12.7 cm (5 inches) thick. A post and chain rail system extended around the top edge of the pit. In the bottom of the pit were concrete blocks with spring bumpers to support the elevator when it was at the bottom of the tower (Figures 24 and 25). The hoist system consisted of the cage guide assembly, cable, and drive assembly. The cage guide assembly extended the height of the tower and consisted of two 15.2 cm wide I beams attached to the tower with brackets. The brackets formed a rectangular frame around the elevator. The I-beams were centered on the east and west sides of the brackets (Figure 26). A bronze guide shoe was mounted within the rail. Attached to the east and west sides of the elevator was a standard guide rail (T-160) that fit with in the guide shoe. The shoe moved up and down within the guide rail. The elevator cable extended from the top of the cage, over the tower cab, and down the opposite side to the hoist drive. Above the tower cab was an 8.6 m (28 ft 41/2 inch) frame with a sheave (approximately 24 inch diameter) at each end (Figure 27). The sheaves supported the cable over the cab. The hoist drive consisted of an electric motor, gear reducer, drive gears, cable drum, overspeed and slack cable switch, and spring buffer (Figure 24). The motor was rated at 50 hp and 900 to 1,800 rpm. It was from Imperial Electric Company of Alhambra, California. The Herring Bone gear reducer was a Link Belt D-110. The drive gear from the gear reducer to the cable drum was a cast steel pinion gear. The cable drum was 3.9 m (12 ft 10 inches) in length and 1.5 m (58 inches) in diameter to the outside flange edge. The center shaft extended 33 cm (13 inch) past each end. The drum drive gear that was driven by the pinion gear was 1.5 m diameter cast steel. The drum and gear were supported by two triangular pedestal bases that were 130 cm (4 ft 2 3/4 inches) along the base, 66 cm (26 inches) across the top, and 42 cm (16 1/2 inches) in height (Figure 28). The overspeed and slack cable switch kept the cable tight during use and regulated the speed of the elevator. The spring buffer in the elevator pit consisted of two springs, rated at 5,000 lbs, on vertical stands that received the weight of the elevator when in the down position. The elevator cage was a steel frame that measured 2.7 x 2.0 x 3.3 m (9 ft x 6 ft 8 inch x 10 ft 11 inches) (Figure 26). The side near the tower and the opposite side of the cage had bi-parting steel gates that were covered with 26 gauge sheet metal covers for winter use. The other two sides of the cage were covered with 18 gauge sheet metal welded to the frame. The floor of the cab was covered with 0.6 cm (1/4 inch) sheet metal welded to the frame. On top of the cage was an overspeed and cable slack safety switch mounted to a friction clutch to keep the cable under tension (Figure 29). According to Holmes and Narver Inc. engineering drawing Y2-T2c-S1, the entire hoist assembly was mounted to a 3.1 x 3.6 m (10 ft 4 inch x 11 ft 10 inch) concrete pad near the northwest leg of the tower (Figure 15).

UNDERGROUND PERSONNEL SHELTERS

Projects 30.6 and 30.7 undertaken by the CETG required the construction of five French and nine German reinforced concrete underground personnel shelters. Data from these projects helped in the development of reinforced concrete dome structures, a dual-purpose garage-shelter, a family shelter, and a modular reinforced brick unit. A French delegation came to the NNSS in 1957 to witness U.S. nuclear tests, culminating in their participation in the Smoky test. French delegates included General Charles Ailleret, the father of the French atomic bomb and General Andre Buchalet, founder and first director of the Military Application Branch of the French Atomic Energy Commission (Figure 30).

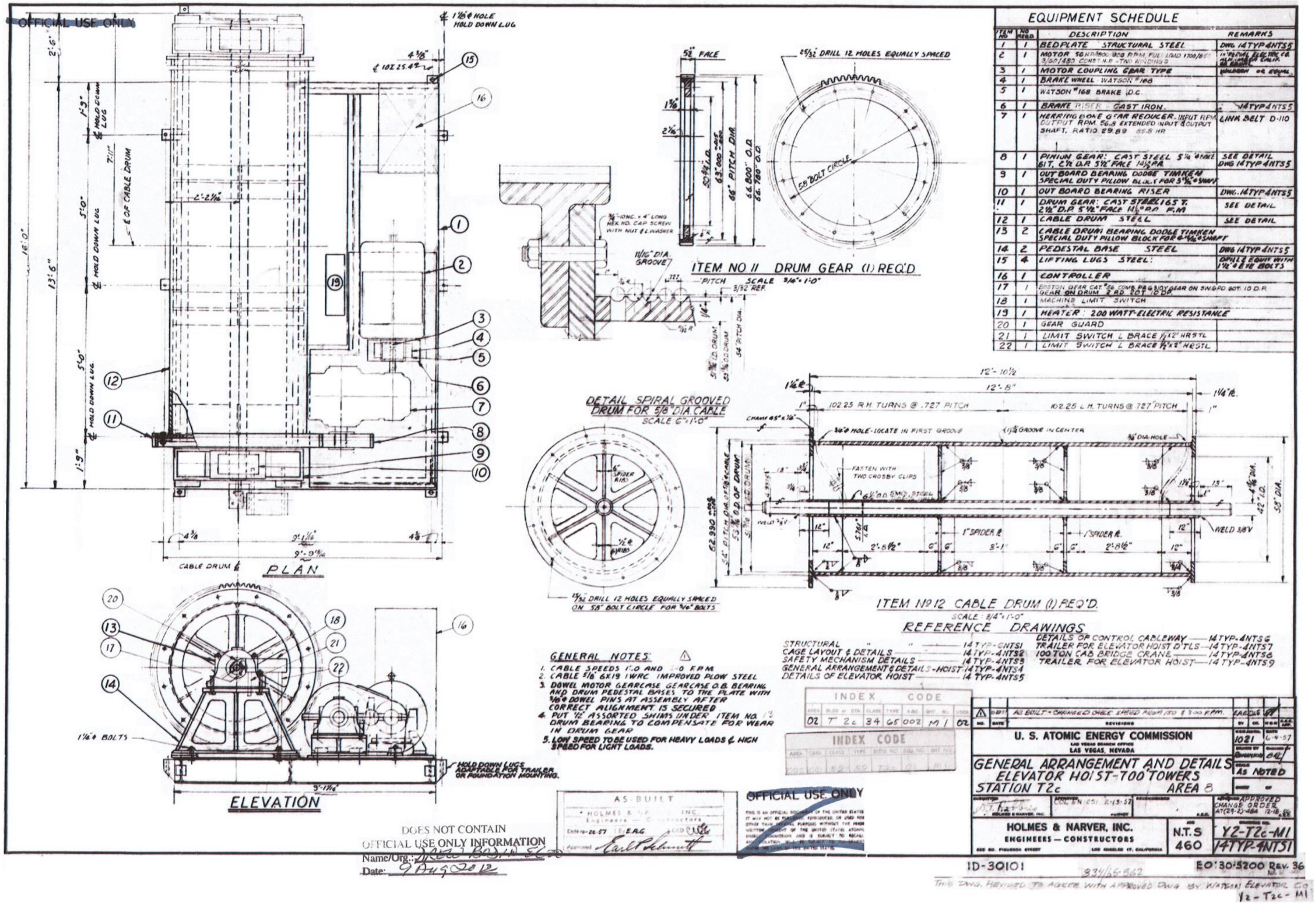


Figure 24. Smoky 700 ft tower general arrangement and details for tower hoist.

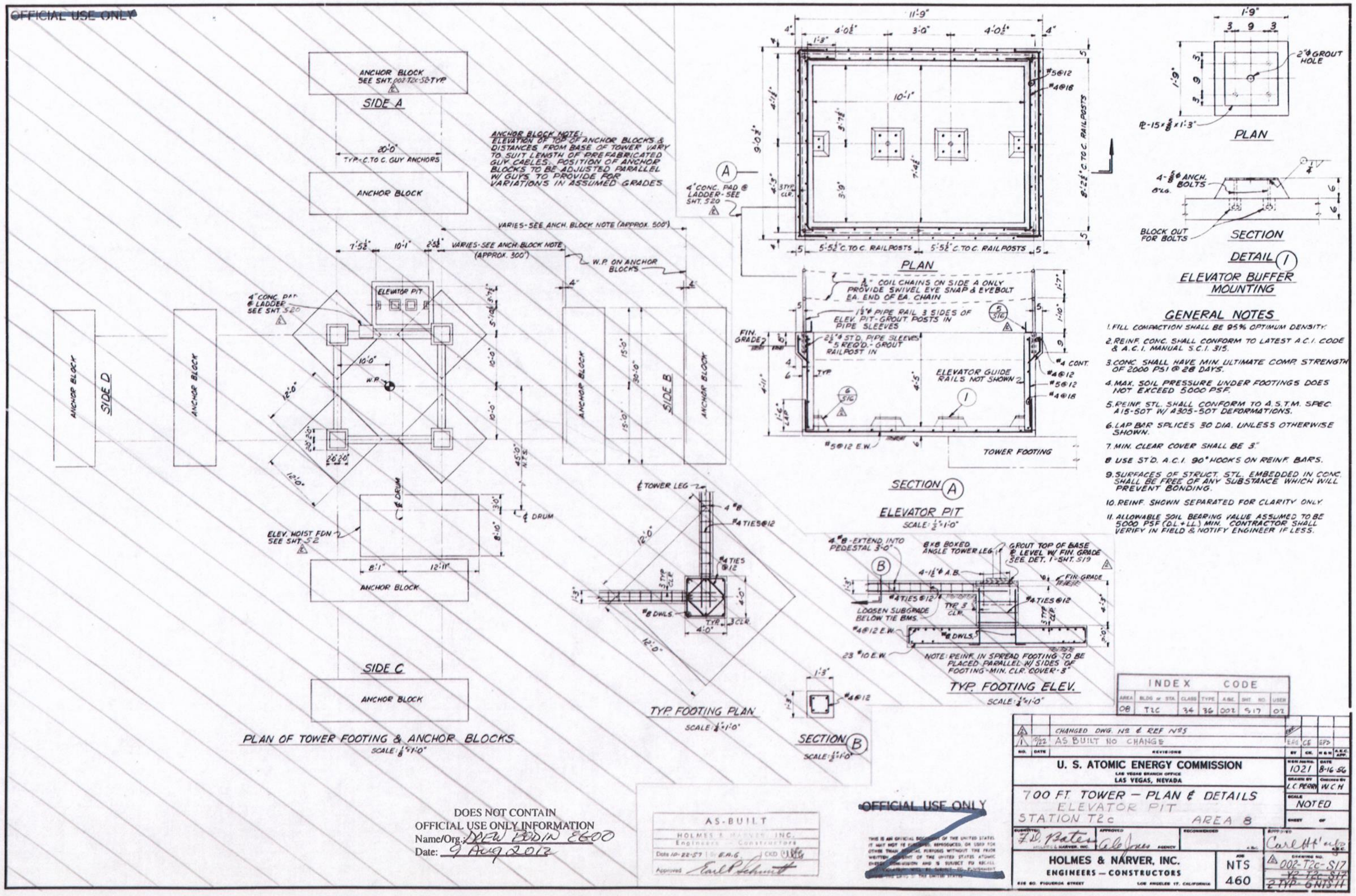


Figure 25. Smoky 700 ft tower plan and details for elevator pit.

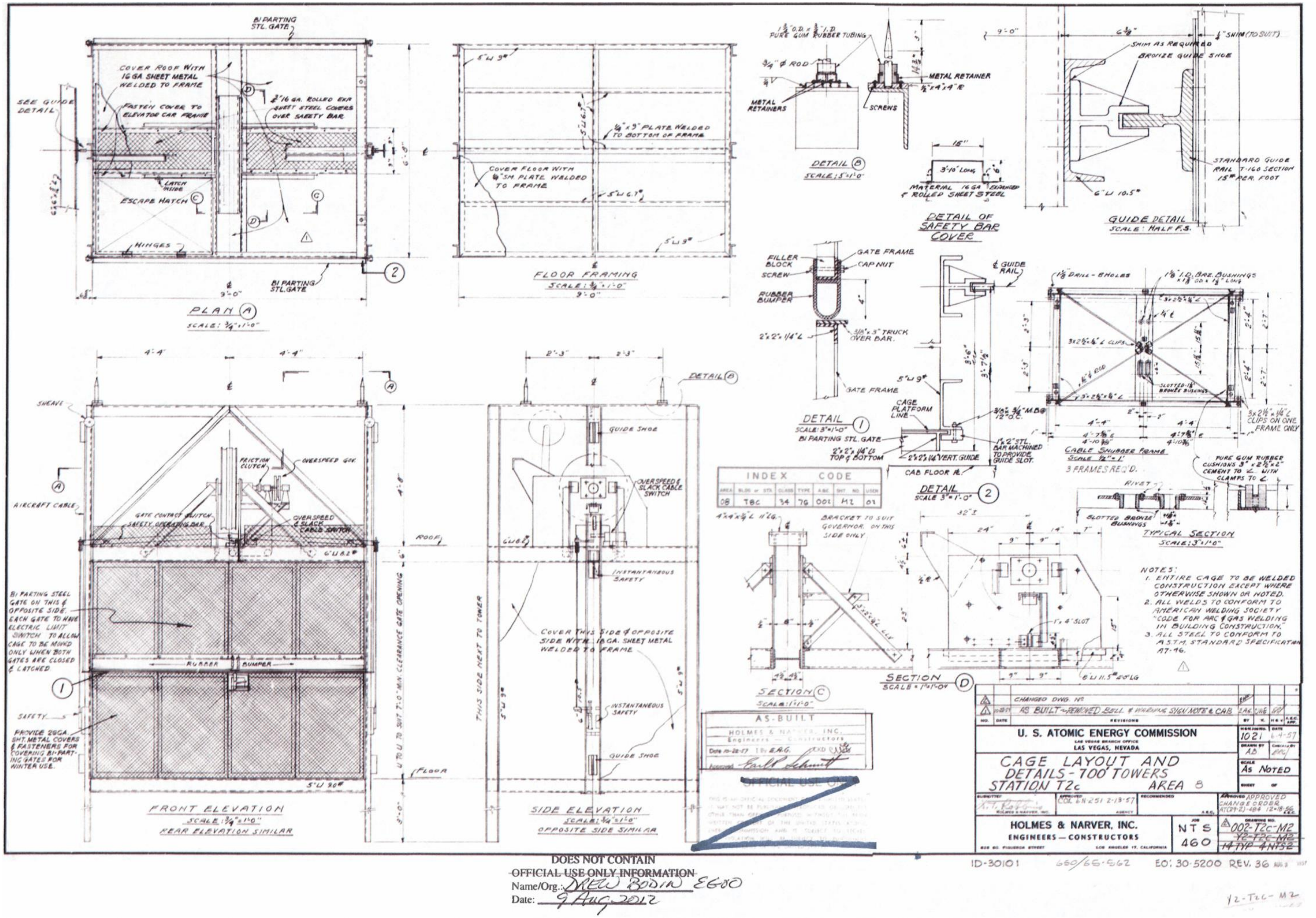


Figure 26. Smoky 700 ft tower cage layout and details.

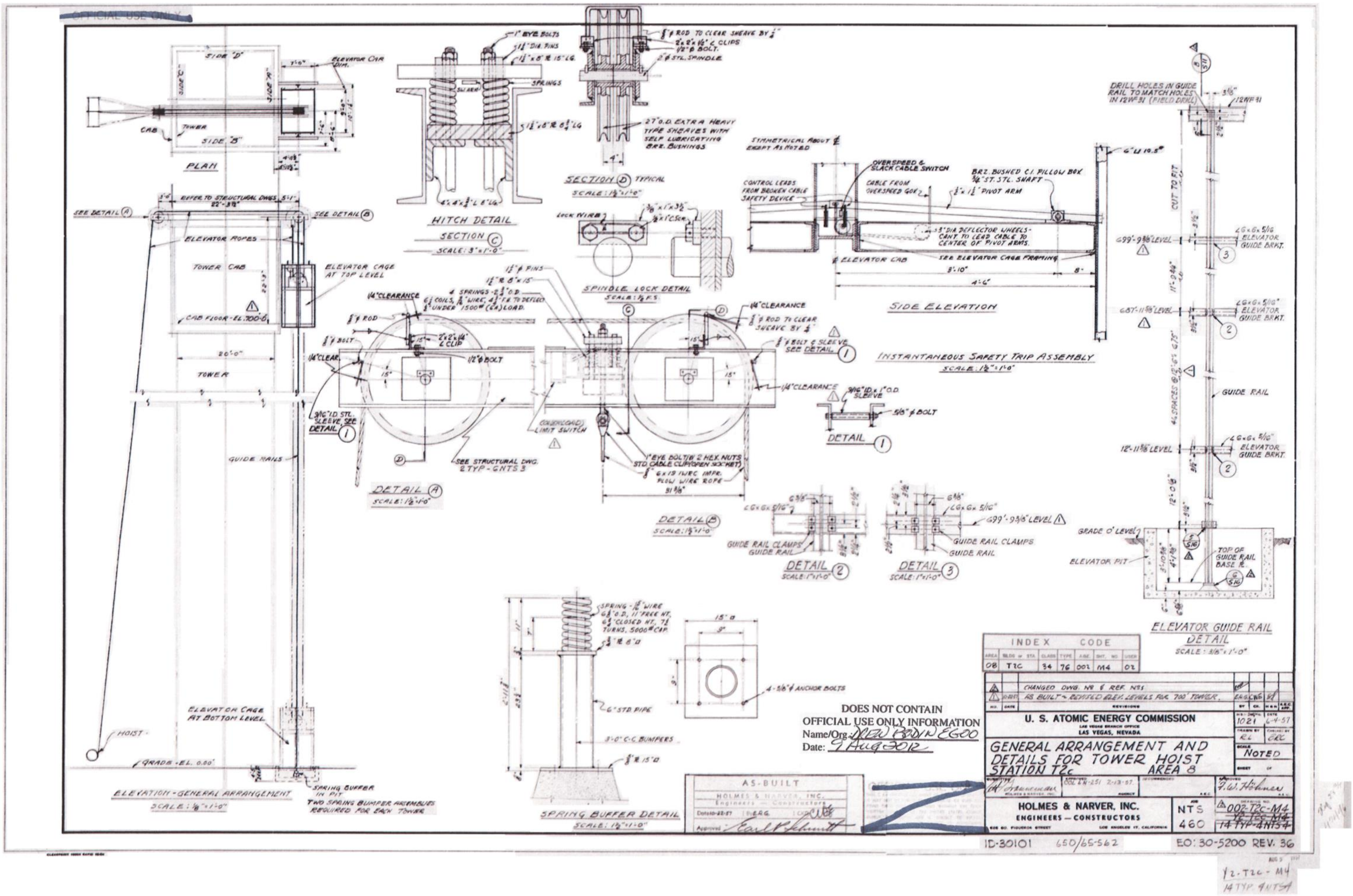


Figure 27. Smoky 700 ft tower cage general arrangement and details for elevator hoist.

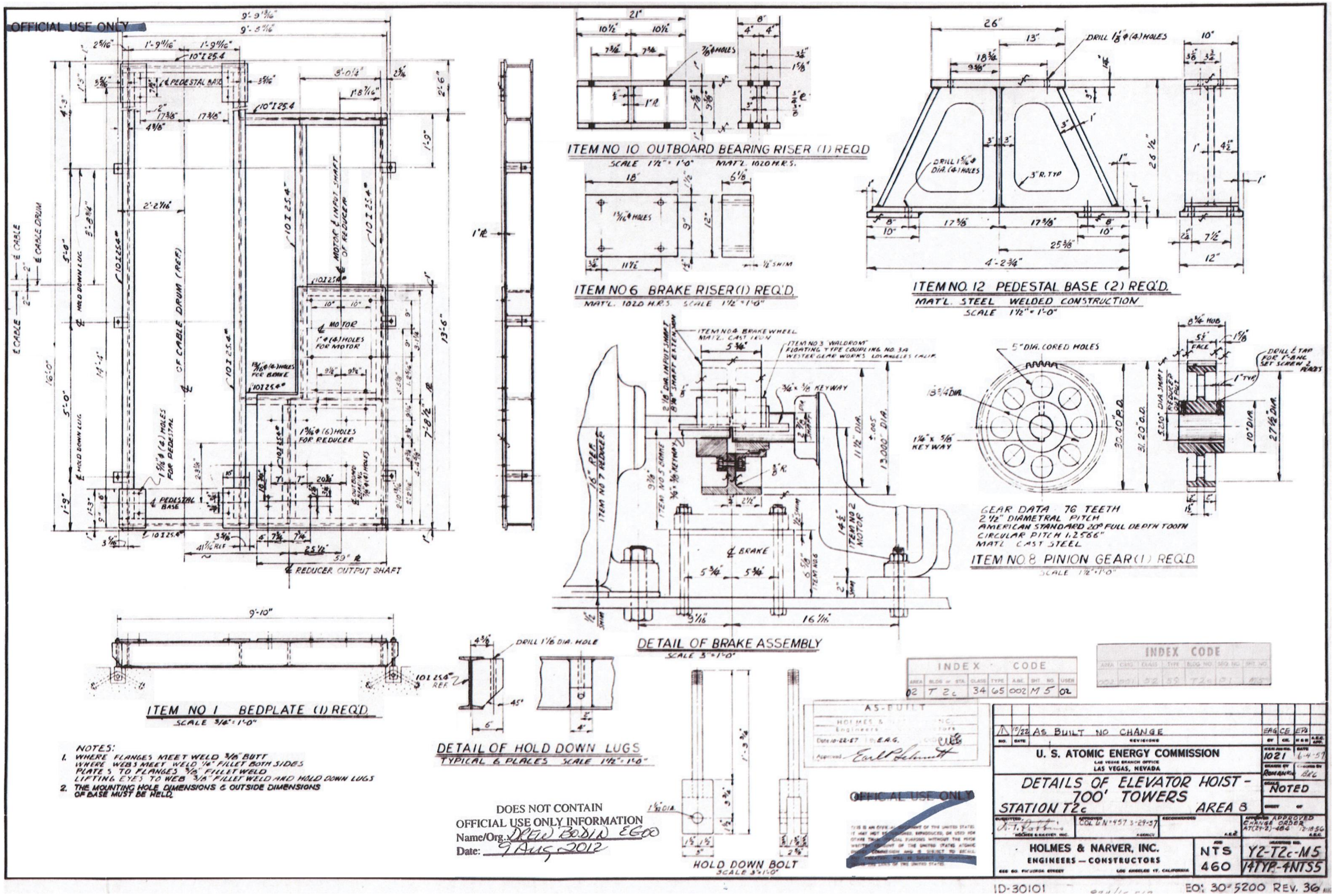


Figure 28. Smoky 700 ft tower details of elevator hoist.

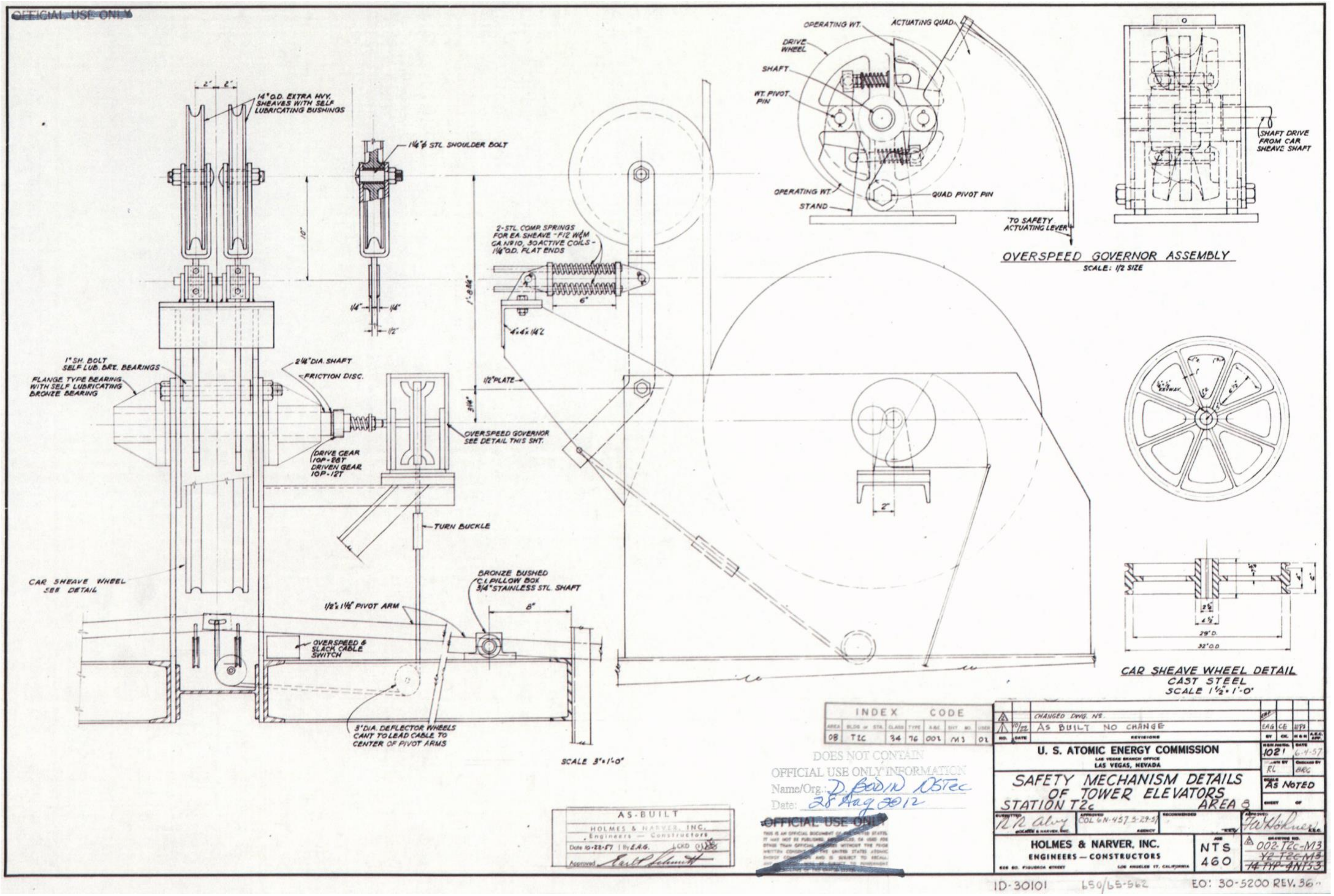


Figure 29. Smoky 700 ft tower safety mechanism.

Figure 30. French delegation at underground personnel shelters, view east (1957, photograph on file at the NNSA/NFO Nuclear Testing Archive, Las Vegas, Nevada).

All work for the French and German underground personnel shelters was done under contract to the AEC by the Sierra Construction Company of Las Vegas, Nevada. Reynolds Electric & Engineering Company supplied the concrete aggregate and miscellaneous work required to make the shelters ready for the test. Holmes & Narver, Inc., provided over-all supervision and coordination as field representatives of the AEC. The Federal Civil Defense Administration and the Service National de la Protection Civile were continuously represented at the NNSS by an Ammann & Whitney field representative, who provided inspection and advisory service for the construction groups.

Concrete was mixed at a central mixing plant operated by Reynolds Electrical & Engineering Company. The plant was a permanent hatcher type installation and was located approximately 24 km (15 miles) from the shelters. The cement used in construction was predominantly type II Portland cement. Wall and roof slab forms consisted of 1.6 cm (5/8 inch) and 1.9 cm (3/4 inch) plywood panels. Dimension stock for studs was 2x4s. Reinforcing steel used in the French shelters consisted of French supplied ADx and TOR bars. The fabrication of the steel was subcontracted by Sierra Construction Co. to Fontana Steel Co. All reinforcing steel was cut and bent at the field fabrication shop near the concrete mixing plant. Structural-steel components consisted essentially of door frames, ventilation equipment, and miscellaneous end items supplied by the French Government. Because of the natural cementation of the soil, excavation of the surface was completed by caterpillar-propelled rippers or explosive charges and by a caterpillar-drawn scraper. Several items were damaged during shipment from France to the NNSS and repaired on site.

Five French reinforced underground personnel shelters (II-1, II-2, II-3, II-4, and II-5) were constructed using specifications provided to Ammann & Whitney. The following is a description of the French underground personnel shelters taken from Cohen and Dobbs (1962). Data from engineering drawings from Cohen and Dobbs (1962) and Holmes and Narver, Inc., have been added to the descriptions below.

French Underground Personnel Shelters

For this project, two types of structures were required, rectangular and circular. Only two of the shelters (II-1 and II-2) were completely built to the specifications of the engineering drawings. The remaining shelters (II-3, II-4, and II-5) were built with entrances (stairs) and antechambers only. Shelters II-1, II-2, II-3, and II-4 were placed, 308 meters (1,010 ft) from the Smoky ground zero, at locations with a predicted overpressure of 132 psi. Shelter II-5 was 321 meters (1,053 ft) south of ground zero in a location with a predicted overpressure of 118 psi. Approximately 15.2 m (50 ft) separated the shelters laterally. Shelters II-1, II-2, II-3, and II-4 were orientated with the long axis of the chamber perpendicular to the blast line and II-5 was orientated with the long axis of the chamber east-west.

For the French shelters, excavation was carried down approximately 7.6 cm (3 inches) below the elevation of the bottom of the base slabs for shelters II-l, II-3, II-4, and II-5, and approximately 30.5 cm (1 ft) below the bottom elevation of the 10 cm (4 inch) setting bed of shelter II-2. The forms for the floor slabs of the cast-in-place portions of the five French test shelters were set to the dimensions of the structures. French reinforcing steel

was then placed within the form work directly over the natural ground. Concrete blocks of the required thicknesses were used to support the bottom layer of steel.

For shelter II-l, the first pour consisted of the floor slab of the emergency exit shaft, emergency exit tunnel, and main shelter and the base slab of the entrance ways, including the stairs. Shelters II-3, II-4, and II-5 had the floor slab of the main chamber and the base slab of the entrance ways poured at the same time. Shelter II-2 had two separate cast-in-place portions. The floor slabs of both of these sections (shaft Tl and shaft T2) were poured at the same time. The second pour of shelter II-1 consisted of the emergency exit shaft walls, emergency exit tunnel walls and roof slab, main shelter exterior wall, partitions and roof slab, and entranceway walls and roof slab. Shelters II-3 and II-5 were also poured complete, with the exception of the portions of the intake and exhaust stacks extending above the roof slab. Shelter II-4 was completed in its entirety by the second pour. Both intake and exhaust shafts of shelter II-2 were poured on August 6, 1957, and the above-grade portion of the exhaust stack was poured two days later. The design of the circular shelter II-2 required that 12 precast circular elements be post-tensioned by means of eight cables.

Minor defects were apparent in each of the three different makes of doors (Dumoulin, Bauche, and Society Cheops). Although the Dumoulin doors for shelters II-l, II-2, and II-5 had the simplest construction details, the blast doors had no provisions for adjustment of the dogs or hinges. Consequently, if either the flat-plate door or the door frame became warped during shipment or erection, it was exceedingly difficult to close the door properly. This situation occurred in the door for shelter II-5 and was partially remedied by grinding the door and door frame down so that the door could be closed with the aid of hand tools. In shelter II-3 three doors (blast, fire-resistant, and gastight) manufactured by the Bauche Co. were used. During trial operations of the mechanical equipment, two handles welded to the latching dogs were broken off by hand pressure (no tools). One each was broken off the fire door and the gastight door. For the Smoky test, the broken handles were put on the inside face of the doors to permit the doors to be closed and dogged from the outside. The fire door was slightly warped and did not set flush against the door frame. The top corner away from the hinges was 0.5 cm (3/16 inch) from the door frame; consequently the adjustment given by the beveled slots in the door frame was insufficient, and the two dogs away from the hinges had to be beveled off to allow the door to be latched. A slightly different problem arose with the dogs on the blast door. With the door open it was possible to put the dogs in a closed position. If the door was shut with the dogs inadvertently in the closed position, the dogs would be slammed against the door frame, and the latches deformed. If bending of the dogs occurred, it would be impossible to latch the door. This situation arose and was remedied in the field by wedging the assembly straight. Shelter II-4 had two doors manufactured by Society Cheops. The blast door and combination fire-resistant gastight door each had four latching pins that were inserted in circular recesses in the door frame. The blast door had no provisions for adjustment of the sliding bolts, and therefore the recesses in the door frame were enlarged to allow the bolts to seat properly. Adjustment provided on the other door was insufficient, and these holes too were enlarged by grinding.

No difficulty was experienced in the installation of the ventilation equipment for shelters II-4 or II-5. In shelter II-3 the dimension of 2.9 cm (l 1/8 inch) from the roof to the top of the vent pipe was changed to 5 cm (2 inch) to allow turning of the top wing nut that holds the sealing cover. Some minor difficulty occurred in the assembly of the ventilation system of shelter II-l. Since cast-in-place ventilation equipment is joined by prefabricated open duct work in the interior of shelter II-l, any error of placement before pouring requires an adjustment of the connecting parts. In II-1 some bending and adjustment of the duct work from exhaust stack No. 1 to the ventilator unit was required. This ventilator was shimmed in position.

Shelter II-1

Shelter II-1 (Station 8-30.6-8001) was a Type 60 rectangular concrete shelter designed for 50 persons at 1.7 cubic meters (60 cu ft) of space for each sheltered person (Figures 31 and 32). It consisted of entrance stairs, an antechamber, the main body, and emergency exit tunnel, and an emergency exit shaft. The ventilation system was a Nessi type and the doors were from Dumoulin. The shelter was 16.8 m (55 ft 2 inches) by 4.2 m (13 ft 9 inches) by 3.5 m (11 ft 5 1/2 inches) in height. It had 0.6 m (1 ft 11 1/2 inch) thick main walls and slab. Entrance was through a two 1 m (3 ft 3 1/2 inches) wide stairways ending at the bottom in a common landing. The roof slab over the stairway was 29.8 cm (11 3/4 inch) thick and the slab over the landing was 40 cm (1 ft 3 3/4) inches thick. Entrance from the landing into the antechamber was through a 0.7 m (2 ft 3 1/2 inch) wide by 1.5 m (4 ft 10 7/8 inch) tall opening. The opening was secured by three doors. On the exterior of the opening was a 4 cm (1 9/16 inch) structural-steel flat-plate blast door. On the interior of the opening were a 17 cm (6 11/16 inch) concrete fire-resistant door and a 0.5 cm (3/16 inch) structural-steel gastight door. The antechamber was 2.6 m (8 ft 6 1/4 inch) by 0.7 m (2 ft 3 1/3 inch) by 2.3 m (7 ft 6 1/2 inches). The opening into the main chamber was 1.8 m (5 ft 10 inches) by 0.7 m (2 ft 3 1/2 inches). It was secured with a 3.2 cm (1 1/4 inch) blast door and a 0.5 cm gastight structural steel door. The main chamber was 24.8 sq m (266.4 sq ft) and is divided into two sections by a 0.4 m (1 ft 3 3/4 inch) by 2 m (6 ft 6 inch) partition. On the opposite end from the main entrance was an emergency exit tunnel. It was an opening 0.6 m (1 ft 11 5/8 inches) wide by 0.8 m (2 ft 7 1/2 inches) high. It was sealed by a 3 cm (1 3/16 inch) steel blast door and a 0.5 cm steel gastight door on each end of the opening. The tunnel was 0.8 m (2 ft 7 1/2 inches) wide by 1 m in height by 4 m (13 ft 3 1/2 inches) in length. It terminated at a 0.8 m square vertical shaft. The shaft opening was sealed by a 0.9 cm (3/8 inch) checkered-plate blast door. Two concrete air-exhaust stacks extended 2.8 m (9 ft 3 1/2 inches) above grade and two intake stacks extended 0.8 m (2 ft 8 1/2 inches) above the ground. Air was drawn from the outside by gravity or electrically through dust filters into an intake fan. The system included two pits filled with sand to filter the air. Each filter contained 1 cubic meter (35.3 cu ft) of clean sand in a 61 cm (2 ft) layer of the air intake. Then the air was passed through an activated carbon filter and aerosol paper. Condensation formed in the sand filter was accumulated at the bottom of the pit and was removed from the pit by a drain with a siphon connected at its end. The water in the siphon prevented the air from being drawn out of the shelter. Air was exhausted through a series of pipes embedded in the walls and propelled by the pressure of the air intake

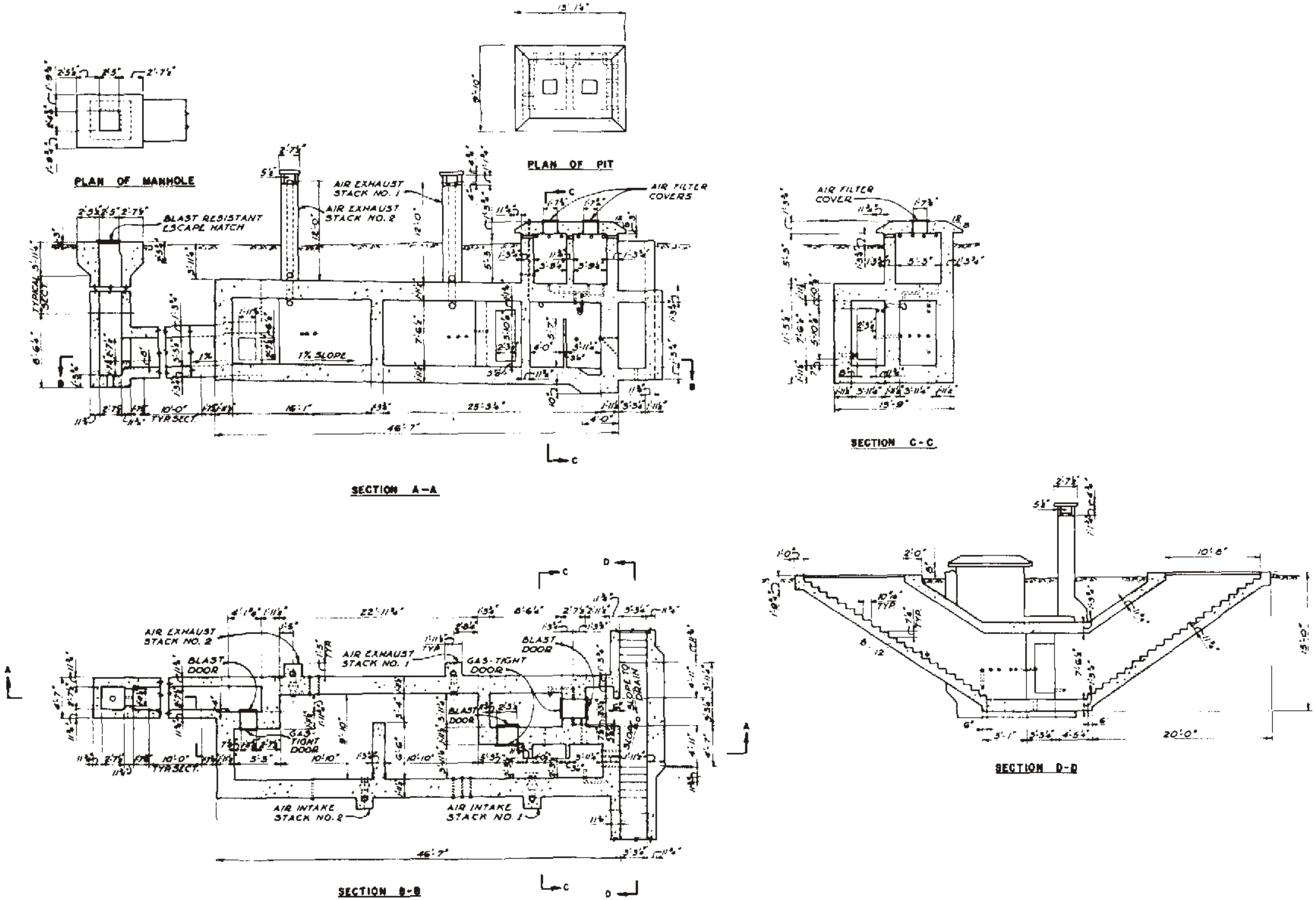


Figure 31. French underground personnel shelter type 60, II-1, architectural layout (Cohen and Dobbs 1962:25, Figure 1.1) [best copy available].

Figure 32. Shelter II-1, view southwest (1957, photograph on file at the NNSA/NFO Nuclear Testing Archive, Las Vegas, Nevada).

system. For the Smoky test, the shelter was equipped with an electrical system powered by two generators located in shelter II-2. Lighting in the shelter was seven 150 watt incandescent bulbs hanging from the ceiling of the main chamber.

Shelter II-2

Shelter II-2 (Station 8-30.6-8002) was a Type 50 circular concrete shelter designed for 32 persons (Figures 33 and 34). It consisted of a main entrance shaft, entrance antechamber, main precast body, exit chamber, and an emergency exit shaft. A spiral steel stair provided access through a vertical shaft 1.8 m (5 ft 10 3/4 inches) by 1.2 m (3 ft 11 1/4 inches), and walls 0.4 m (1 ft 3 3/4 inches) thick. The shaft was secured (at grade level) by a horizontally sliding steel-plate door blast door that is 4 cm (1 9/16 inches) thick. At the bottom of the shaft were a second blast door 3.2 cm (1 1/4 inches) thick and a gastight door. The opening from the shaft into the antechamber was 0.7 m (2 ft 3 1/2 inches) wide by 1.8 m (5 ft 11 inches) high. The antechamber was 1.8 m by 1.2 m by 2.2 m (7 ft 2 3/4 inch) high. The main body of the shelter was 6 m (19 ft 6 3/8 inches) in length and was constructed of 12 circular precast reinforced concrete sections 2.7 m (8 ft 10 1/4 inches) in outside diameter, 25.4 cm (10 inches) thick, and 0.47 m (1 ft 6 1/2 inches) in length. The sections were placed on a concrete-setting bed and tensioned with eight cables by the Freyssinet method. The Freyssinet Prestress Post-Tensioning systems was a method of inducing known permanent stresses in a structure or member before the full or live load is applied. These stresses were induced by tensioning the High Tensile Strands, wires or rods, and then anchoring them to the member being Prestressed, by mechanical means. Joints between the sections were 3.8 cm (1 1/2 inches) and filled with slow setting concrete mortar. A bearing stress of 8.6 kg/cm^2 (122 psi) was placed on each section by tensioning the cables. At the end of the chamber was a 1.4 m (4 ft 7 3/4 inch) by 1 m by 2 m (6 ft 9 1/2 inch) exit chamber. Access into the exit shaft was by a 0.6 m (1 ft 11 1/4 inch) by 0.8 m (2 ft 7 1/2 inch) opening. It was sealed by a 2 cm (13/16 inch) steel blast door on one side and a 0.8 cm (5/16 inch) steel gastight door on the other side. The exit shaft extended 2.3 m (7 ft 8 1/2 inches) above ground level. The entire shelter was covered by 1.4 m (4 ft 9 inches) of soil. Air ventilation was the Nessi system as in the previous shelter. Air was drawn down a pipe equipped with a ball type dual-action antiblast valve and an intake fan. Air was forced by gravity or electric fan into the main chamber. A quick-acting shut-off valve regulated the air flow. Exhaust was through the exhaust stack fitted with overpressure and antiblast valves. A sand-filter pit containing a filtered-air system was located above the antechamber. The air was drawn through 34.5 cu ft of sand by means of the intake fan. The air was passed through an activated-carbon filter and aerosol paper before it was passed to the main chamber. Condensation formed in the sand filter was accumulated at the bottom of the pit and removed by a drain with a siphon connected at its end, as in shelter II-l. The water in the siphon prevented the air from being drawn out of the shelter. Electrical power during the test was supplied by one of two gasoline-engine-driven generators located in the main chamber. The exhaust system of the generator set was connected to an exhaust pipe placed at the position usually occupied by the overpressure valve at the interior end of the exhaust stack. The overpressure valve was removed to minimize the chance that the exhaust gases might back up in the chamber and stall the generator engines.

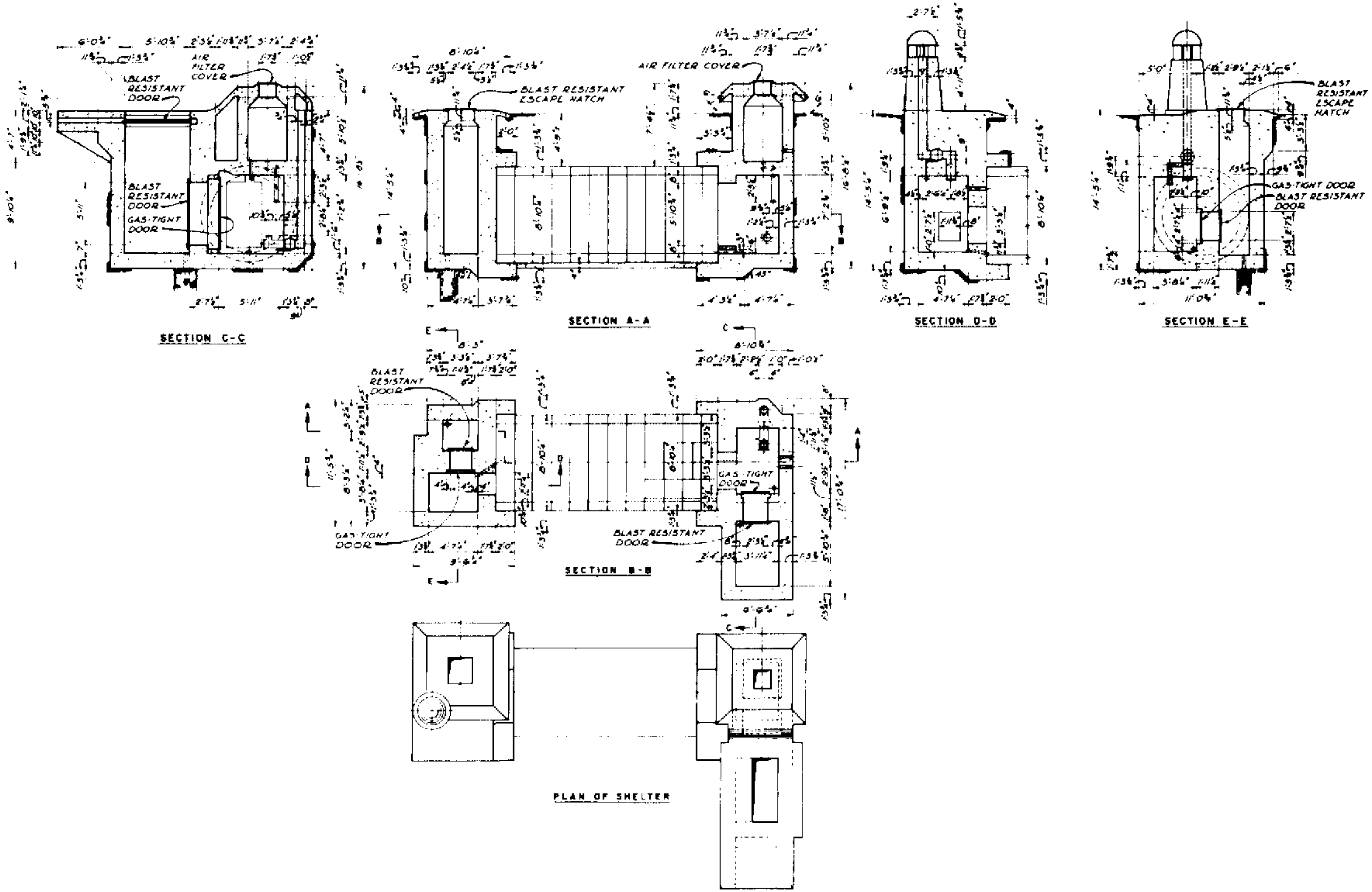


Figure 33. French underground personnel shelter type 50, II-2 (Cohen and Dobbs 1962:26, Figure 1.2) [best copy available].

Figure 34. French underground personnel shelter II-2, view northwest (1957, photograph on file at the NNSA/NFO Nuclear Testing Archive, Las Vegas, Nevada).

Shelters II-3, II-4, and II-5

Structures II-3 (Station 8-30.6-8004), II-4 (Station 8-30.6-8005), and II-5 (Station 8-30.6-8003) were poured-in-place reinforced concrete entrances (stairs) and antechambers only (Figures 35-37). They were similar in design to shelter II-1. These shelters were used for comparative evaluation of the adequacy and effectiveness of three different types of doors, and well as ventilation equipment. The ventilation systems were for use in the main chambers but placed in the antechambers for this test. The ventilation of shelter II-3, made by Aeric, consisted of two pipes (intake and exhaust) protected by reinforced-concrete stacks. The stacks extended 0.9 m (3 ft) above the ground surface. Each pipe contained a back- pressure flap valve that was closed by the blast pressure and remained closed until the external pressure approached the natural atmospheric condition. The Nessi ventilation system of shelter II-5 was similar to the ventilation in shelters II-1 and 11-2. It consisted of one air intake and one exhaust pipe, both protected by reinforced concrete. The intake and exhaust stacks extended 0.8 m (2 ft 7 inches) above the ground surface. The pipes of the ventilation system were fitted with ball type automatic antiblast valves. Shelter II-4 was provided with a second Nessi type ventilation system, similar to the ventilation system located in shelters II-l, II-2, and II-5, consisting of a single reinforced concrete stack containing one 0.8 m diameter pipe with a ball type antiblast valve. The doors for shelter II-5 were the same as two of the Dumoulin doors (blast and gastight) used at the entrance of shelter II-1. Shelter II-4 had entrance doors made by Society Cheops; these included a blast door and a combination fire-resistant gastight door at the opening to the chamber. The blast door on the exterior side of the opening and the combination fire-resistant gastight door on the interior side of the opening were bolted tight to the concrete by bolts passing through sleeves provided in the concrete around the perimeter of the opening. Bauche doors were used for shelter II-3. These consisted of blast, fire-resistant, and gastight doors, each on a separate frame. Frames for the doors were installed after the main structural concrete pours are made.

Instrumentation

French diagnostic instruments were placed in the structures and used to determine pressure, deformation and vibration, stresses and strains, heat, nuclear radiation and contamination, and miscellaneous readings for communication and lighting. The equipment consisted of 33 BRL self-recording pressure-time (SRPT) gauges and two self-recording very low pressure-time (VLP) gauges. The gauges, which were placed both inside and outside the shelters and in the entrance ways, were distributed among the shelters in the following manner: shelter II-1 9 SRPT gauges and 1 VLP gauge, shelter II-2 4 SRPT gauges and1 VLP gauge, shelter II-3 2 SRPT gauges, shelter II-4 11 SRPT gauges, and shelter 11-5 7 SRPT gauges. Twelve shock gauges and protecting canisters were used during the Smoky test. The shock gauge was a self-contained mechanical unit requiring no electronic or communication channels. The gauge was protected by a circular canister 0.6 m (2 ft) in diameter and approximately 0.6 m deep. Vertical and radial gauges to record free-field effects were placed approximately 0.3 m (1 ft) below the ground surface at various distances from ground zero. During the Smoky test, one radial and one vertical gauge were placed in the underground rectangular shelter II-1 for Project 30.7 at the 306 m (1,005 ft) range. The canisters were bolted to the floor slab of the structure.

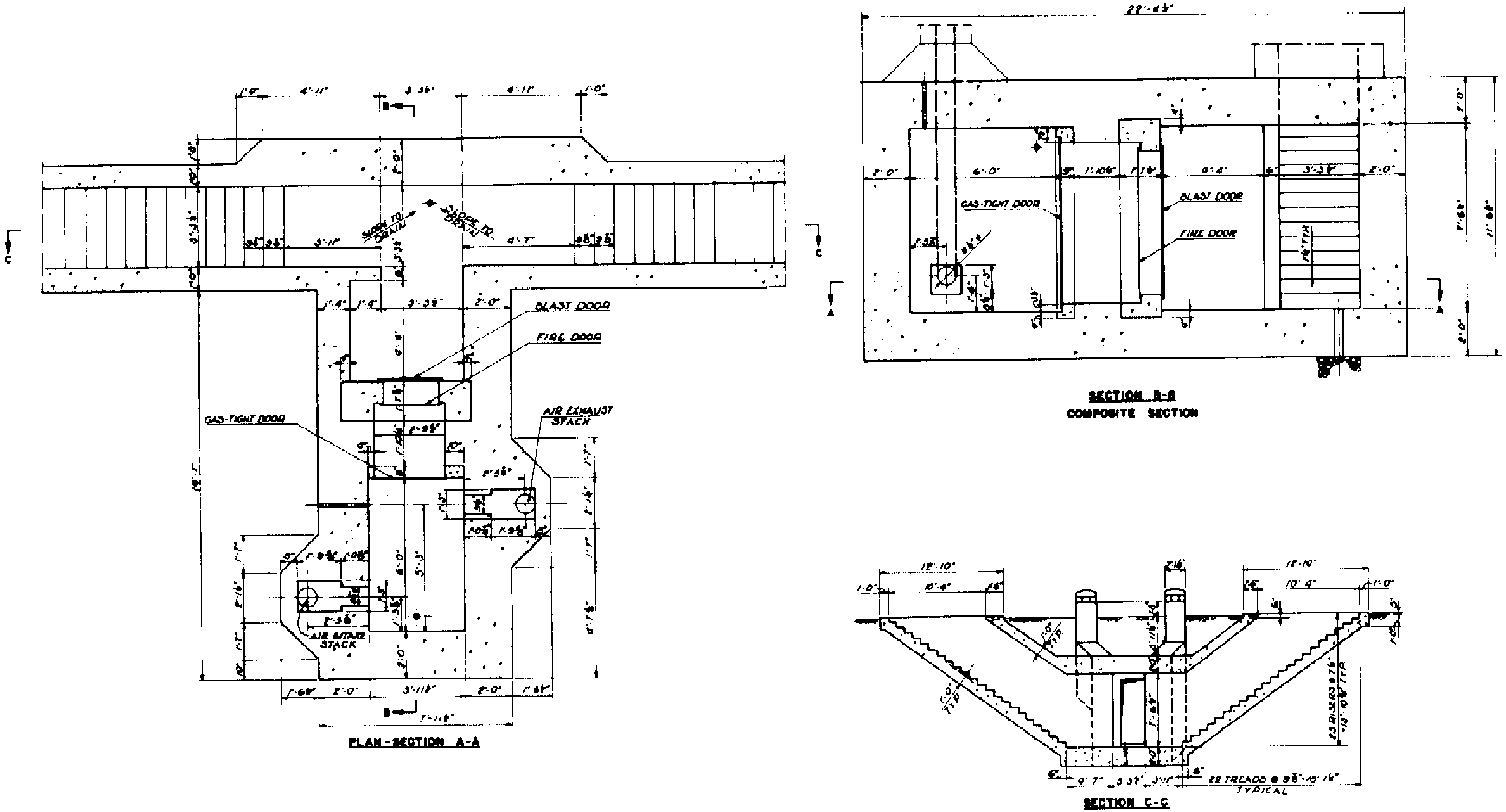


Figure 35. French underground personnel shelter II-3 (Cohen and Dobbs 1962:27, Figure 1.3) [best copy available].

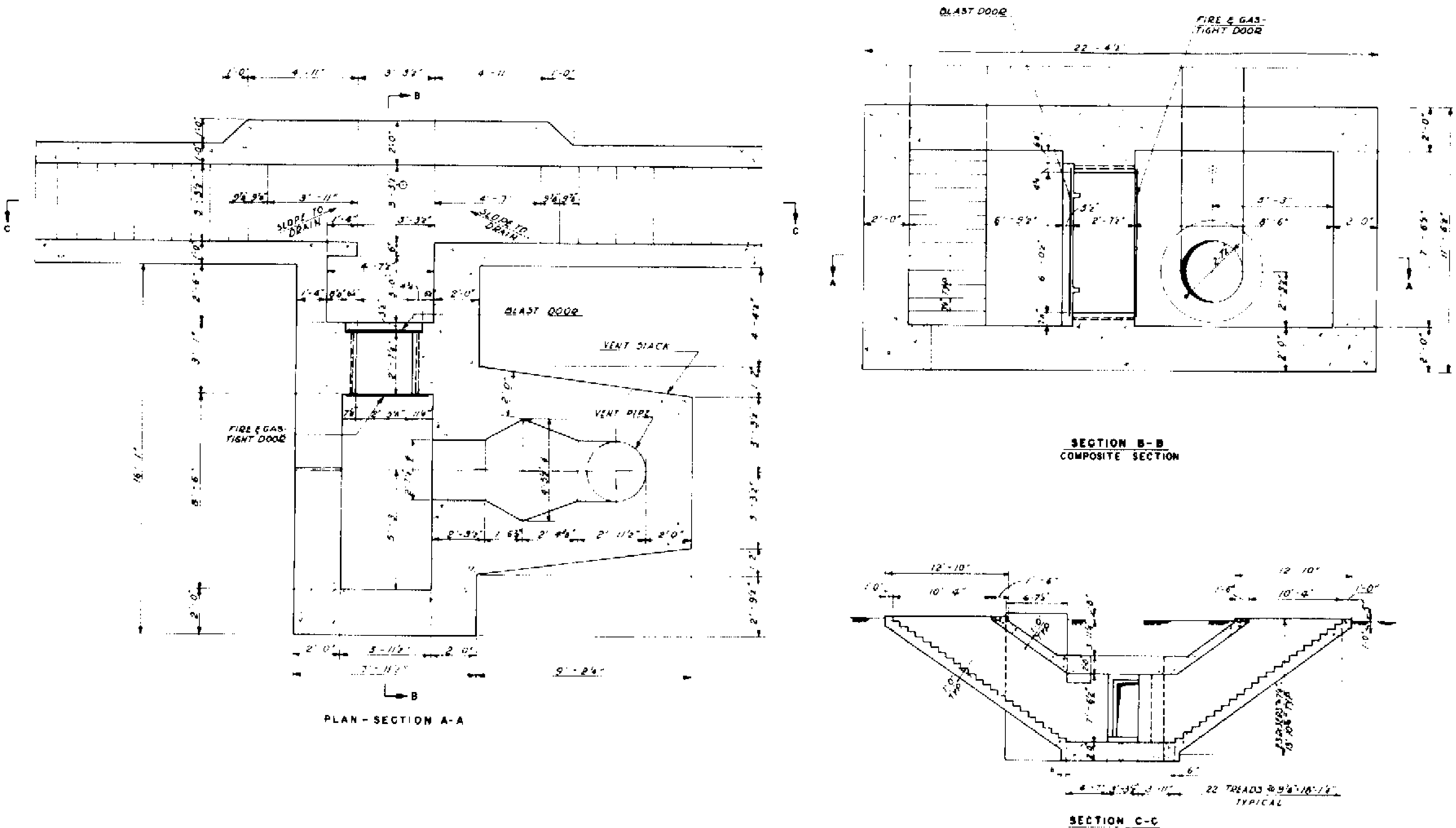


Figure 36. French underground personnel shelter II-4 (Cohen and Dobbs 1962:28, Figure 1.4) [best copy available].

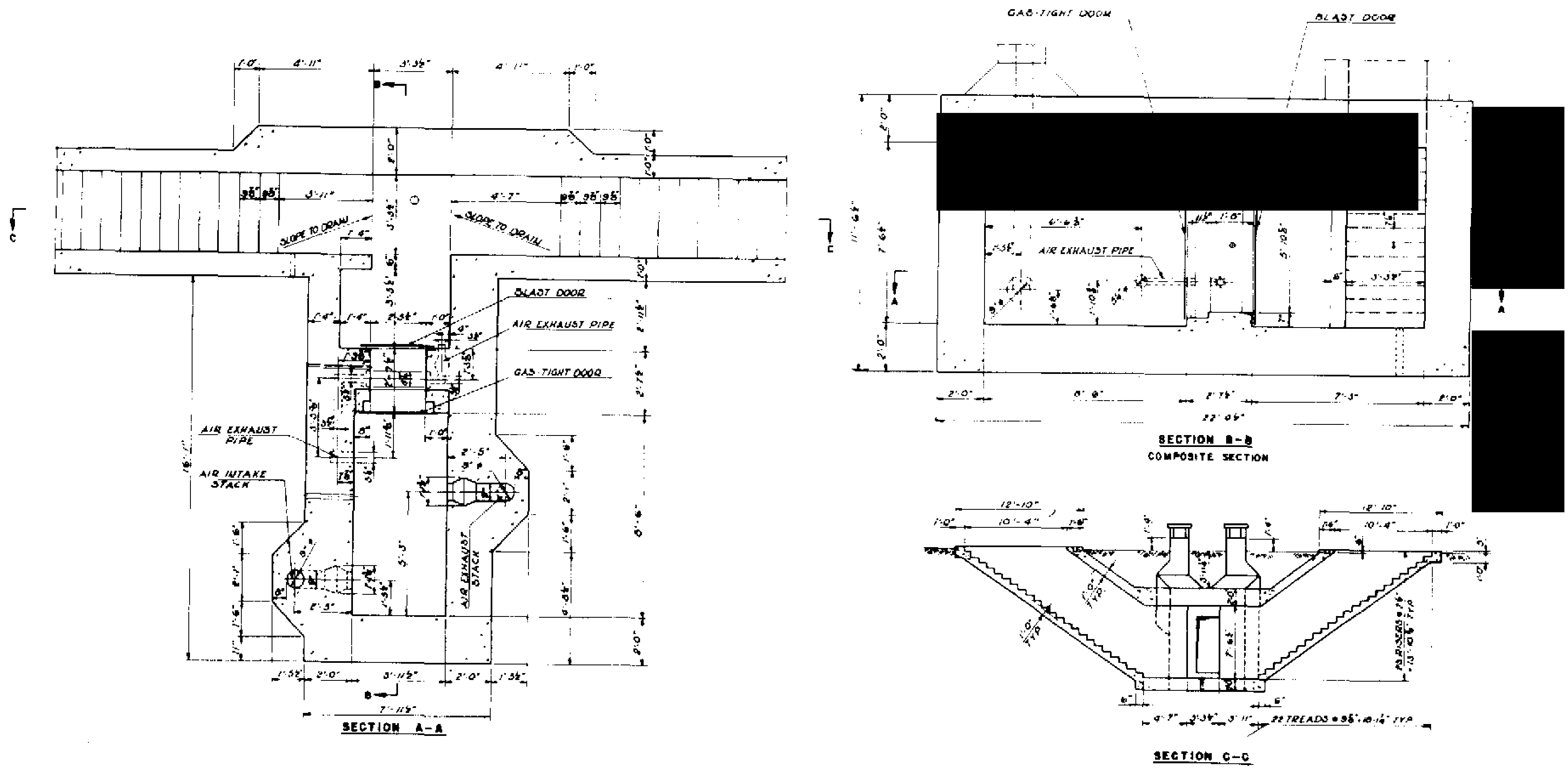


Figure 37. French underground personnel shelter II-5 (Cohen and Dobbs 1962:29, Figure 1.5) [best copy available].

One radial and two vertical gauges were placed adjacent to the shelter; a distance of 1.5 m (5 ft) was used between gauges. Project 33.6 consisted of placing five samples of 20 mice, one sample in each shelter. The objectives were twofold: (1) to place biological specimens in the shelters and to follow their mortality rate over a 60-day period and (2) if possible, to relate the cause of death, if any, to a specific environmental factor.

Experiment Results

The designs of all shelters were made by French engineers in accordance with French design and construction practices to provide protection against the effects of atomic and thermonuclear detonations. The criteria used were those of a static loading condition, and the required thickness of concrete and quantity of reinforcement was obtained by an ultimate strength method of design. The dynamic effects upon the stresses of the members, the additional strain energy available in the elasto-plastic and plastic ranges, and the pressure-time variation were not considered in the actual design. The structures, along with the roofs, floors, and walls, were designed to withstand the same uniform pressure. A uniform negative pressure was also considered in the design for reversal. Actual conditions that would exist in France were simulated by utilizing procedures of construction similar to those used in France and by using reinforcing and structural steel, doors, and ventilation equipment shipped from France.

Although visual observation indicated no large movements of the main body of any of the five shelters tested, the shock spectra data indicated substantial vertical and horizontal motions. The actual incident overpressure at the predicted pressure levels was lower than predicted and less than the static design overpressure. In shelters II-1 and II-2, the maximum recorded internal pressures were 0.03 kg/cm^2 (0.4 psi) and 0.05 kg/cm^2 (0.7 psi), respectively. Both of these shelters had the sealing covers on the interior ends of the ventilation pipes blown off by the shock wave. The maximum internal pressures recorded in shelters II-3 and II-5 were both equal to 0.1 kg/cm^2 (1.4 psi), even though two basically different types of blast closures were used. The ventilation pipe and blast closure in shelter II-4 was similar in design to that in shelters II-l, II-2, and 1I-5, but was of a much larger size. Maximum internal pressure recorded in shelter II-4 was 0.8 kg/cm^2 (12.0 psi). The interior volumes of shelters II-3, II-4, and II-5 were approximately equal. With the exception of shelter II-2, all the test structures sustained very slight damage. Cracking was observed in all shelters, but major damage occurred only to those portions exposed to the shock front such as the entrances and the ventilation projections.

The permissible level of the initial radiation with the shelters was assumed to be 20 to 70 roentgen equivalent man (REM). No readings of the initial radiation were obtained as separate values but the values for the total gamma dosage during the first 52 hr after the detonation at various points within the five test structures were within the prescribed allowable. It was not possible to obtain thermal measurements from the instrumentation provided. The non-electronic gauges exposed to the thermal wave were scoured by debris carried by the blast wave and were unreadable. In some cases the recording elements were removed from their mountings by the blast wave. As a result of a breakdown in an electronic recorder, no results were obtained from the electronic temperature gauges. Residual thermal effects were not apparent from visual observation. The postshot photos taken before the entrance ways were cleaned showed a deposited dust layer that varied in

thickness from approximately 0.6 cm to a maximum of 5 cm and some rubble was also present. Interior dust was observed only at the bases of the ventilation ducts.

Nine German reinforced underground personnel shelters (RAa, RAb, RAc, RAd, RCa, RCb, RCc, CAa, and CAb) were constructed using specifications provided to Ammann & Whitney. The following is a description of the German underground personnel shelters taken from Cohen and Bottenhofer (1960).

German Underground Personnel Shelters

This project included three types of underground cast-in-place concrete personnel shelters: (1) Rectangular Type A shelter, designed for an overpressure of 9.3 kg/cm^2 (132 psi); (2) Circular Type A shelter, designed for 9.3 kg/cm^2, and (3) Rectangular Type C, designed for 10.3 kg/cm^2. Nine structures were built, four rectangular Type A shelters (RAa, RAb, RAc, and RAd), two circular Type A shelters (CAa and CAb) and three rectangular Type C shelters (RCa, RCb, and RCc).

Rectangular Type A

The rectangular Type A shelter was designed for 25 persons with general over-all dimensions of 4.2 m (13 ft 9 inch) wide by 0.9 meters (35 ft 5 inch) long by 3.5 meters (11 ft 5 1/2 inch) high. The reinforced concrete shelter consisted of two entryways, a vestibule, the main shelter body, an exit chamber, an emergency-exit tunnel, a vertical exit shaft, and a ventilation shaft (Figures 38 and 39). The two entryways were oriented north-south. The south entryway consisted of 1.4 meter (4 ft 7 inch) wide stairs and the north entryway was a 6 meter (19 ft 8 inch) long ramp. Both entryways led to a common landing in front of the shelter. The stairway and ramp walls and slabs were 30 cm (11 3/4 inches) thick. Entrance from the landing into the vestibule was through a 0.9 meter (2 ft 10 1/2 inch) by 1.9 meter (6 ft 1 3/4 inch) opening, which was closed on the exterior side by means of a steel arch type blast door. The vestibule, 2 m (6 ft 6 3/4 inch) by 1.5 m (4 ft 11 inch) by 2.3 meters (7 ft 6 1/2 inch) high, provided an air lock for entry into the main chamber. Entrance into the main chamber was through a 0.9 meter (2 ft 10 inches) by 1.9 m (6 ft 1 3/4 inch) opening, which was closed by a gas-tight fire door. The main body of the shelter had a floor area of 3 m (9 ft 10 inches) x 4 m (13 ft 1 1/2 inch) and was 2.3 m (7 ft 6 3/4 inches) high. The walls, floor slab, and roof slab were 0.6 m (1 ft 11 1/2 inches) thick. The roof slab had a 1.2 m (4 ft) earth cover for radiation protection. An emergency exit was provided through an exit chamber at the opposite end of the shelter. The exit chamber was entered through a 0.65 m (2 ft 1 3/4 inch) by 0.85 m (2 ft 9 1/2 inch) gas-tight fire door. The chamber was 0.9 m (2 ft 11 1/2 inch) by 1 m (3 ft 3 1/4 inch) by 2.3 m (7 ft 6 1/2 inch) high. Access from the exit chamber into the emergency-exit tunnel was through a 0.65 m (2 ft 1 3/4 inch) x 0.85 m (2 ft 9 1/2 inch) opening provided with a blast door on the exterior side. This tunnel, 2.1 m (7 ft) long, had a cross section of 0.8 m (2 ft 7 1/2 inches) x 1.6 m (5 ft 3 inch), with 30 cm (11 3/4 inch) thick walls, roof, and floor slab. It led to a vertical shaft, 0.8 m (2 ft 7 1/2 inch) square with 30 cm (11 3/4 inch) thick walls, which provided access to the ground surface. Adjacent to the exit chamber was a 1.5 m (4 ft 11 inch) square reinforced concrete air intake shaft, extended to grade level. This shaft provided filtered air for the protected ventilation system of the structure, which normally operated during blast conditions.

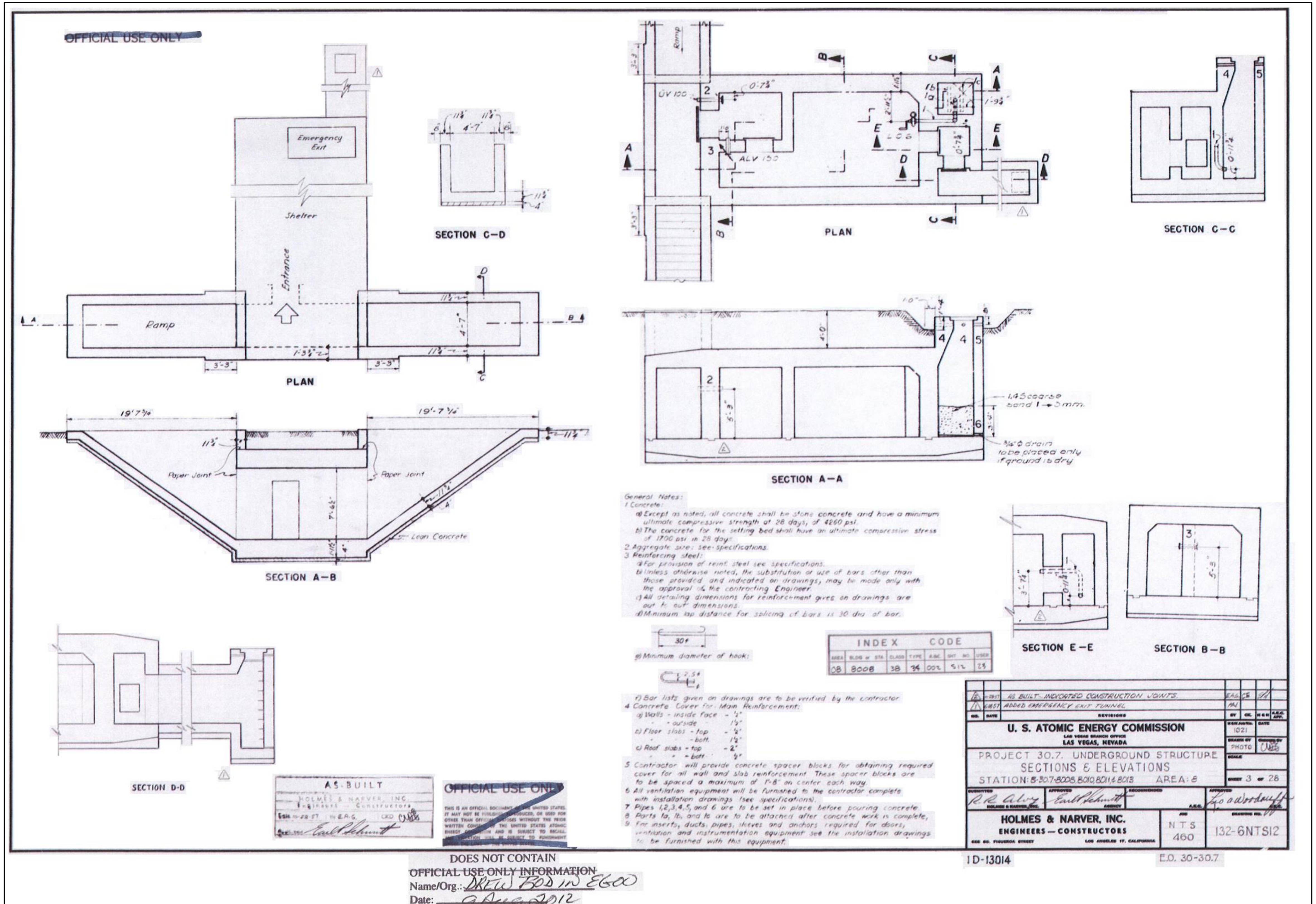


Figure 38. German underground personnel shelter Type A, rectangular.

Figure 39. German rectangular Type A shelter, view northwest (1957, photograph on file at the NNSA/NFO Nuclear Testing Archive, Las Vegas, Nevada).

Circular Type A

The circular Type A reinforced concrete shelter consisted of a protected entranceway, a vestibule, the main body of the shelter (25 persons), an exit chamber, and a combination emergency exit and ventilation shaft (Figure 40). The over-all length of the cylinder was 13.6 m (44 ft 7 1/2 inch). The vestibule and the main chamber were of circular cross section, with an interior radius of 1.25 m (4 ft 1 1/4 inch) and 0.53 m (1 ft 3/4 inch) thick walls. Radiation protection was provided by 1.6 m of earth cover over the shelter. The shelter was entered by means of a covered stair with 30 cm (11 ¾ inch) thick walls, stair slab, and roof slab. Entrance into the vestibule was through a 0.9 m (2 ft 11 ½ inch) by 1.87 m (6 ft 1 3/4 inch) steel arch type blast door. Entrance from the vestibule to the main chamber was through a 0.9 m (2 ft 11 ½ inch) by 1.87 m (6 ft 1 3/4 inch) gastight fire door. At the rear of the shelter, the exit chamber could be entered through a 0.65 m (2 ft 1 ¾ inch) by 0.85 m (2 ft 9 ½ inch) gastight fire door, and from this chamber access was made to the exit shaft through a 0.65 m (2 ft 1 ¾ inch) by 0.85 m (2 ft 9 ½ inch) blast door. Exit to the surface was provided by this shaft, which had 30 cm (11 ¾ inch) thick walls and a 62 cm (2 ft 1/2 inch) square opening at the top, which was closed by a steel cover or grating. Adjacent to the exit shaft was the filtered air intake chamber, which provided protected ventilation during blast conditions.

Rectangular Type C

The rectangular Type C shelters (25 persons) were made with reinforced concrete. The overall dimensions, excluding the emergency tunnel, are 6.19 m (20 ft 4 inch) by 5.4 m (17 ft 8 1/2 inch) by 2 m (6 ft 6 3/4 inch) high (Figure 41). The shelter consisted of the double entranceway (ramp and stair) leading to a common landing, the entrance vestibule, the main body, the exit chamber, and the emergency-exit tunnel and exit shaft. The entrance stair and ramp were similar to those of the Type A rectangular shelter. Entrance into the vestibule was through a 90 cm (2 ft 11 ½ inch) by 1.9 m (6 ft 1 3/4 inch) blast door. The vestibule was 1.3 m (4 ft 3 1/4 inch) by 1 m (3 ft 3 1/4 inch) by 1.98 m (6 ft 6 3/4 inch). Entrance from the vestibule into the main chamber was through a 0.8 m (2 ft 7 1/2 inch) by 1.98 m (6 ft 6 3/4 inch) opening. The main chamber was 3.2 m (10 ft 6 inch) by 4 m (13 ft 1 1/2 inch) by 1.98 m (6 ft 6 3/4 inch) high. The walls, floor slabs, and roof slab were 30 cm (11 ¾ inch) thick. Radiation protection was provided by 0.9 m (3 ft) of earth cover. An opening (with no door) at the rear of the shelter provided access to the 1.3 m (4 ft 3 1/4 inches) by 1 m (3 ft 3 1/4 inch) exit chamber, from which entrance could be gained to the 2.13 m (7 ft) long emergency exit tunnel through a 0.65 m (2 ft 1 ¾ inch) by 0.85 m (2 ft 9 ½ inch) blast door. The emergency tunnel had a cross section of 0.8 m (2 ft 7 1/2 inch) by 1.6 m (5 ft 3 inch), with 30 cm (11 ¾ inch) thick walls and slabs. Exit from the end of the tunnel to the grade above was through a 0.8 m (2 ft 7 1/2 inch) square vertical shaft, which was closed by a hinged cover or grating to prevent debris from falling into the shaft. Adjacent to the exit chamber was the filtered-air intake chamber, which was 1.3 m (4 ft 3 ¼ inch) by 0.8 m (2 ft 7 ½ inch) by 1.98 m (6 ft 6 ¾ inch) high.

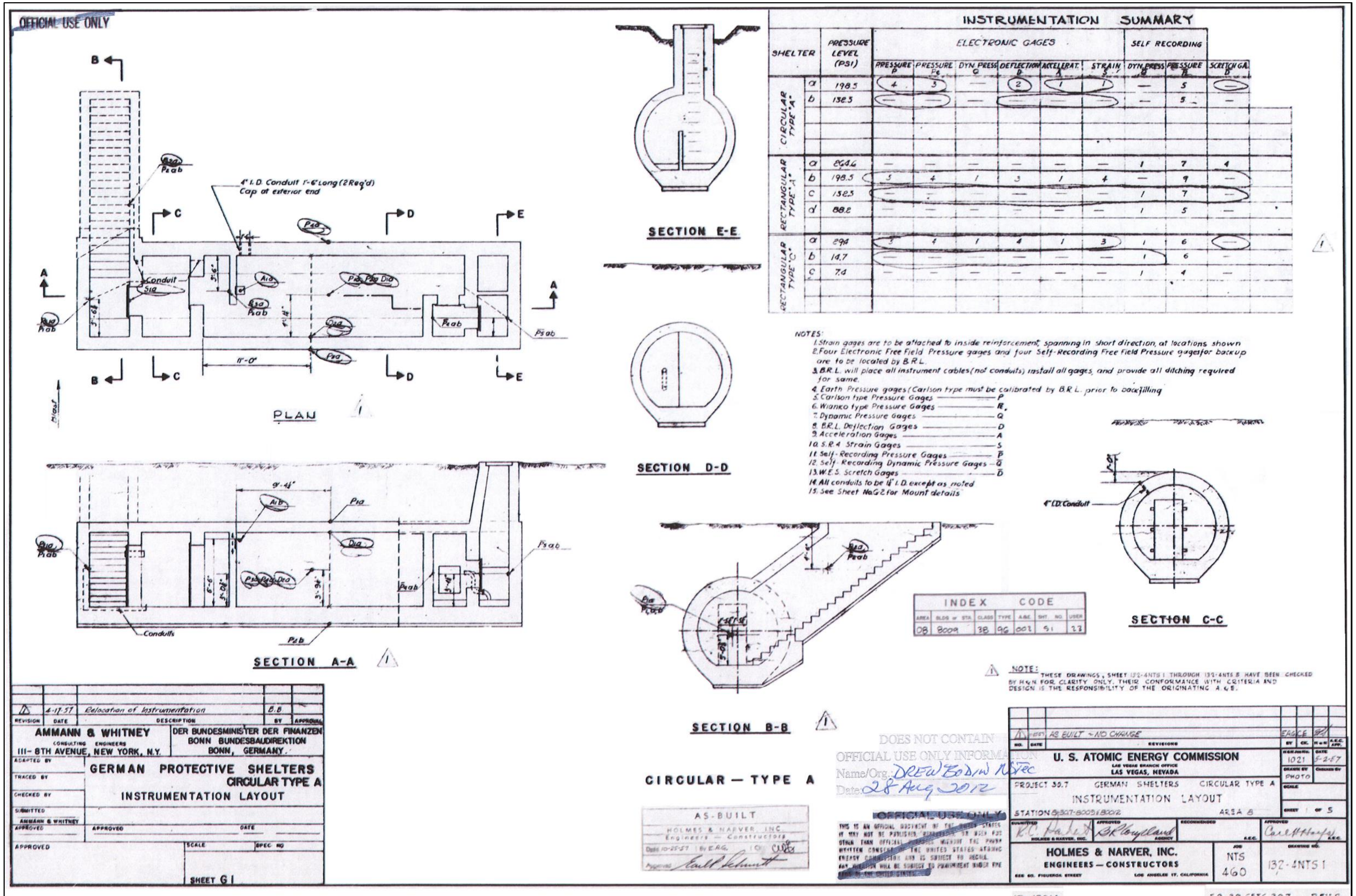


Figure 40. German underground personnel shelter Type A, circular.

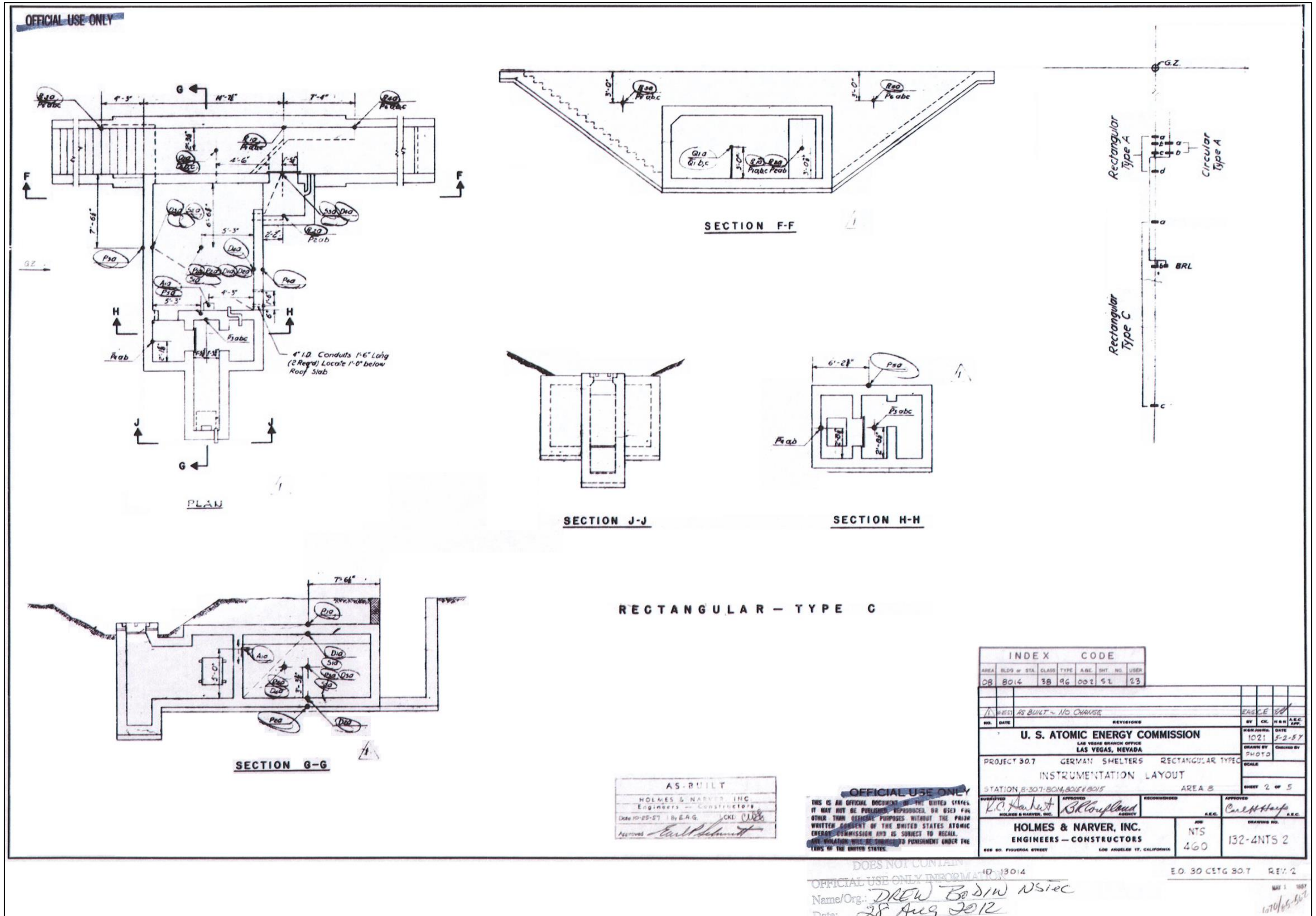


Figure 41. German underground personnel shelter Type C, rectangular.

Ventilation

Ventilation for all three types of shelters (rectangular Type A, rectangular Type C, and circular Type A) was similar. Although the structures were designed for the use of two systems (natural and filtered air), only the filtered-air system was used. With this system, air entered four 5 cm (2 inch) pipes that passed through the air-intake stack at the ground surface. The air passed down and through 1 m of double-washed coarse sand. The filtered air was then pumped into the main chamber of the structure by an air pump located 1.1 m (3 ft 7 1/2 inches) above the floor slab. In the shelters that have a gastight door between the main chamber and antechamber (rectangular and circular Type A), the foul air was exhausted at the entrance end of the main chamber by an exhaust valve. Foul air in the vestibule (antechamber) was removed from the structure by means of an overpressure flap valve through the exterior wall into the entranceway. A calibrated flowmeter indicated the quantity of air passing through the pump. When the flow indicator was held steady at its center position, the quantity being drawn in was 750 liters/min (198 gal/min). A greater flow exceeded the functional capacity of the coarse sand filter. When the air pump was operated, the throttling valve was placed in the fully open position, and the quantity of air was regulated. During the Smoky test, all throttling valves were left fully open. Also, the exhaust valves in the four rectangular Type A and two circular Type A shelters were left open 1 cm.

Doors

The main blast doors of the structures are of two types. The main entrance doors of the rectangular Type A and the circular Type A shelters consisted of a plate curved inward with tubular members across to act as struts to take the compressive forces when the curved plates of the door were put into tension by the blast loads. The second type blast door, used for the main entrance of the Type C shelter and a smaller size for the emergency exits of all the structures, was a flat plate with horizontal stiffeners. Although placed at various pressure levels, the blast doors for the rectangular Type A and the circular Type A structures were designed for an overpressure of 15.5 kg/cm (220 psi). The blast doors for the rectangular Type C structure were designed for an overpressure of 4.6 kg/cm (66 psi). The vertical and horizontal emergency-exit blast doors were designed for 10.3 and 0.9 kg/cm (147 and 13 psi), respectively. The fire doors are made of two flat plates, with a fire-resistant material between. The whole assembly was 2.85 cm (1 1/8 inch) thick. All doors, both blast and fire, were made gastight by rubber-tubing gaskets. Recesses left in the concrete to receive the frame anchorages permitted the installation of the door frames after the structural concrete was placed. Doors were manufactured by Mannesmann-Stahlblechbau, West Germany.

Instrumentation

Most of the instruments in the German shelters were manufactured in the United States and were shock gauges, pressure gauges, displacement and acceleration gauges, strain gauges, and dosimeters. Five self-reading pressure gauges were supplied by the West German Government. In addition, a biological experiment consisted of a sample of 20 mice; one sample was placed in seven of the nine structures tested. The test objectives were twofold: (1) to place the specimens in the shelters and to follow their mortality rate over a 60-day period post-shot and (2) if possible, in case of death, to relate the cause of death to a specific environmental factor.

Experiment Results

Very slight damage was sustained by the test structures in the shelter areas. Cracking was observed in all structures, but major damage occurred only to those portions exposed to the shock wave, such as the entrances and the rectangular Type A and circular Type A emergency-exit covers. An analysis of the damage was undertaken using current ultimate- strength theory and was performed using the material strengths as determined from test results, the reinforcement placement and structure dimensions as obtained from the as-built drawings, and the recorded incident pressure at the location of the structure as the loading. The analysis indicates that only minor cracking was expected and agrees with the actual post-shot condition.

The West German Government assumed that the permissible level of the initial radiation within structures RAc, CAb, and RCb was to be 25 roentgen equivalent in man (REM). REM is a unit used to measure the dose equivalent, which combines the amount of energy with the medical effects of the given type of radiation (U.S.NRC 2014). For gamma radiation the factor is 1. The total gamma dosages during the first 52 hours after the Smoky detonation were recorded. Structure RAc had radiation dosages equal to 145 r (roentgen) at the front wall (exposed to the exterior), 47 r by the interior corner of the antechamber, and 22 r at the center of the main chamber. Structure CAb had interior dosage values varying from 9 r to 29 r, except directly behind the gastight door, where the dosage was 140 r. The interior dosages in structure RCb varied from a minimum of 36 r at the rear corner to a maximum of 382 r directly inside the main blast door.

The mice were recovered from the seven structures two days after the test. Upon recovery and examination of the mice, if death had occurred, the body and spleen weights were recorded, and the entire organism was fixed in buffered formalin. Average weights of the surviving animals for each location were taken daily by getting the total weight for each group and dividing by the number in the group. All of the mice in structure CAb were found dead upon recovery. The cause of death was attributed to carbon monoxide poisoning produced by the gasoline generator that operated the air sampler. The location, number, time of recovery after the test, and time of death of the mice that died between their recovery and 20 days after the test were recorded.

ASSOCIATED PROJECTS

Approximately 2,800 personnel were at Mercury in Area 23 and were responsible for performing AEC and DOD's AFSWP activities (Harris et al. 1981a:12). At Camp Desert Rock, 3,000 military personnel were responsible for conducting military maneuvers, training, and technical projects (Harris et al. 1981a:12). The Smoky test was fired from the control center at CP-1 in Area 6 approximately 24 km (15 miles) from the Smoky tower. All personnel were at least 12.8 km (8 miles) from ground zero. After firing, the radiological safety personnel began mapping of the contaminated areas around ground zero, then scientific experiments were recovered, and finally the military ground troops began their activities.

The three main Federal agencies participating in the Smoky test were the AEC with the two weapons laboratories, LANL and LLNL; the FCDA with the CETG; and the DOD with the AFSWP. The AEC was the directing agency and conducted 16 separate scientific and diagnostic experiments. Four projects were undertaken by LANL and were radiochemistry sampling and temperature measurements. Twelve projects conducted by LLNL were radiochemistry sampling and rocket sampling. The FCDA conducted research for the safety of civilians with 22 projects. These were instrumentation, biological, and radiological studies. The AFSWP conducted research of military importance with 10 projects. Defense Nuclear Agency (1981:4-5) lists approximately 1,566 participants from the DOD including members of the AFSWC and Exercise Desert Rock (EDR) troops at the Smoky test. However, Harris et al. (1981b:83) lists 2,232 personnel participating in the Exercise Desert Rock VII and VIII activities for the Smoky test. Robinette et al. (1985:20) list 3,741 participants for the Smoky test. Air Force Special Weapons Center personnel flew cloud sampling and tracking missions and controlled air operations and Exercise Desert Rock involved troops to develop tactics for the nuclear battlefield (Harris et al. 1981a:10; Harris et al. 1981b:4).

For Smoky, the AEC and DOD formed the Nevada Test Organization (NTO) which contained elements of the AEC, FCDA, and DOD and was headed by the AEC Test Manager (Harris et al. 1981a:13). The NTO personnel fired the shot, performed the weapons-development test, military effects test, and civilian tests while military and scientific personnel were assigned to staff activities (Harris et al. 1981a:13). Other support came from the AEC Support Director who operated Mercury and coordinated contractor support; the DOD Support Director who assisted AFSWP; the AFSWC provided air support for all aspects of the project; and the DOD Operations Coordination Group was the contact point between NTO and Exercise Desert Rock commanders (Harris et al. 1981a:14). Exercise Desert Rock was composed entirely of DOD personnel from military units stationed at Camp Desert Rock and they participated in Desert Rock VII and VIII exercises (Harris et al. 1981a:14). These personnel were under the direction of the Desert Rock Exercise Director, the Commanding General of the Sixth Army. This position wall filled by the Deputy Exercise Director and Camp Commander of Camp Desert Rock, Brigadier General William A. Jensen (Edwards 1997:100; Nevada Test Organization 1957:30). The NTO and Exercise Desert Rock operated independently and were coordinated by the Deputy Chief of Staff, Weapons Effects Tests, AFSWP for the AEC Test Manager (Harris et al. 1981 b:2; Harris et al. 1981a:14-15).

EXERCISE DESERT ROCK

Exercise Desert Rock involved troop exercises, troop observer indoctrination programs, training projects, and technical service test projects. Two troop exercises were planned for Smoky, Task Force BIG BANG and Task Force WARRIOR, but only Task Force WARRIOR was undertaken.

Task Force BIG BANG

Task Force BIG BANG was under the direction of the U.S. Army Human Resources Research Office (HumRRO) and designed to test a soldier's ability to accomplish a typical task after viewing an atmospheric nuclear test (Harris et al 1981a:16). This included disassembling and reassembling a rifle, throwing a grenade, and crossing an infiltration course that was thought to be contaminated with fallout from the nuclear test. However, because of the delays in the test schedule and unfavorable wind direction toward the trenches on the day of the test, the soldiers were rescheduled to participate in the Galileo test on September 2, 1957 (Harris et al. 1981a:3) and viewed the Smoky test from News Nob in Area 6 (Harris et al. 1981a:25).

Task Force WARRIOR

Task Force WARRIOR (Project 50.1) was designed as an air-landed attack and resupply maneuver (Figure 42). No personnel were to be in the test area during the Smoky test and all areas that were utilized by the project were determined safe by radiological monitors prior to the troops entering the area. Participating in the project were 1,144 personnel (Harris 1981a:26). The exercise was comprised of an attack team (Pathfinder Unit) entering an area north and west of ground zero and being supplied by helicopters prior to their attack of the objective area. The exercise would end when the attack team reached the limits of the cleared or safe area (Harris et al. 1981a:17). A provisional unit comprised of elements of the 1st Battle Group, 12th Infantry Regiment, 4th Infantry Division of Fort Lewis, Washington was restructured to form Company C, 1st Battle Group, 12th Infantry Regiment (Harris et al. 1981a:26).

In late July the unit was assigned to the Smoky test and training in air-landed operations began. The troops were trained in loading men and equipment into helicopters and they rehearsed the operation. On August 12 and 13, 1957, the troops began preparing their defensive positions in the areas designated for the Smoky test (Harris et al. 1981a:27). These were 115 locations for the soldiers, communications equipment, vehicles, and weapons. Items at the locations were to be inspected after the shot to determine how effectively they were protected. Positions ranged from 820 m (2,690 ft) to 1,850 m (6,069 ft) to the west and north of ground zero. Troops from the 84th Engineer Construction Battalion used military type digging equipment and spent approximately 7.5 hours digging trenches (Harris et al 1981a:27; Harris et al 1981b:102). The ground in the Smoky area is rocky and difficult to dig using hand tools. Only about 60 percent of the positions were completed. All activities were completed by August 16, 1957, but contamination from the Shasta test postponed the scheduled August 18 date for at least 10 days (Harris et al. 1981a:27). On August 23, 1957, the troops observed the Doppler atmospheric nuclear test in Area 7 from trenches 2,606 m (8,550 ft) from ground zero (Harris et al. 1981a:27).

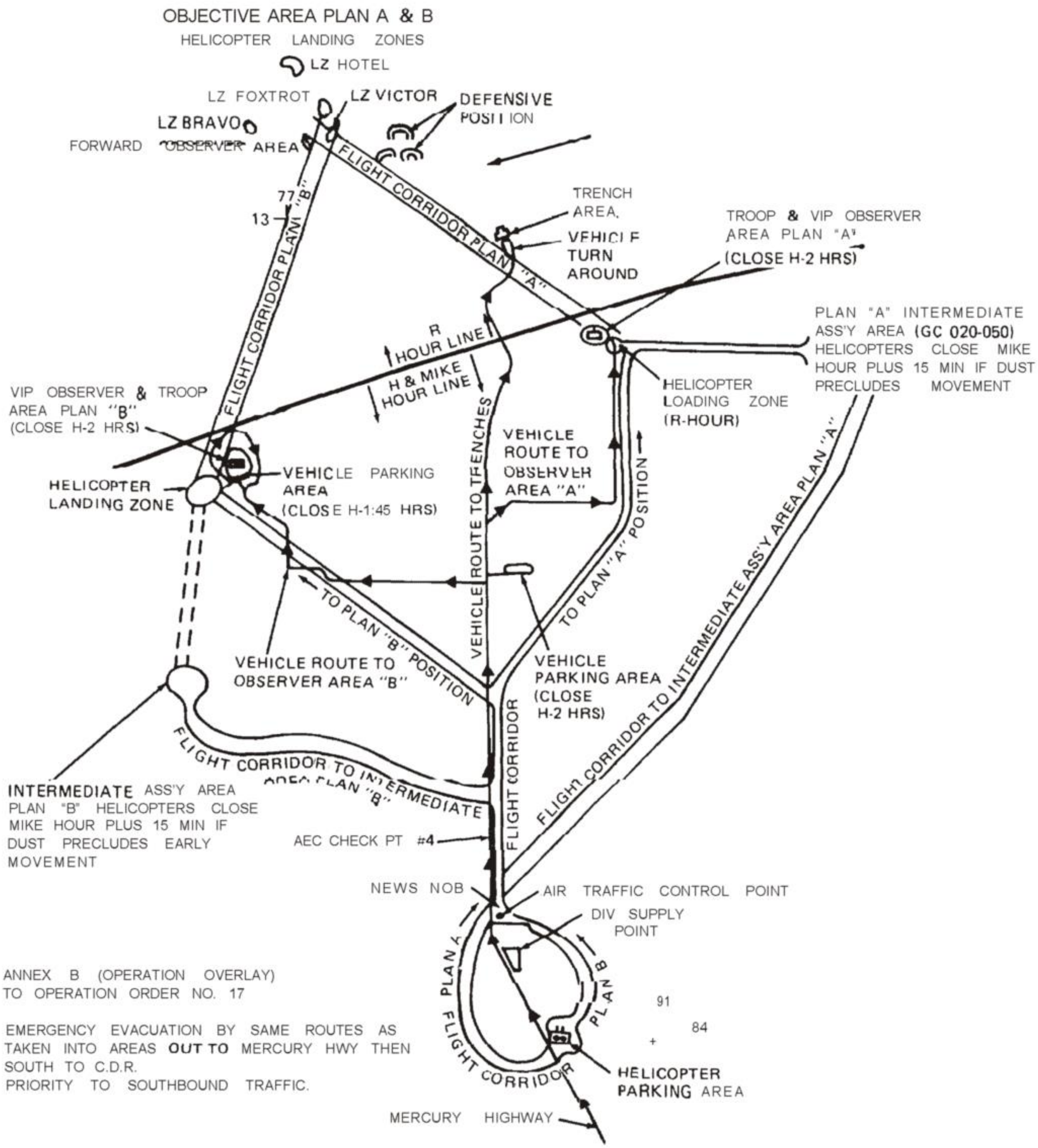


Figure 42. Project 50.1 combat team exercise (infantry battle group) shot Smoky (Harris et al. 1981a:34).

As a part of Task Force WARRIOR, trenches had been dug 4,023 m (13,200 ft) southeast of the Smoky tower in Area 9 for the HumRRO project. However, weather conditions predicted for the area indicated the wind direction would be to the southeast and carry the fallout across the trench locations causing serious radiological control problems (Harris et al. 1981a:32-33; Harris et al. 1981b:100). The task force troops observed the Smoky test from an area along Pahute Mesa Road, the 3rd Transportation Battalion was redirected to the control point in Area 6, and the HumRRO troops watched from News Nob and waited until the Galileo test to perform their exercise (Harris et al. 1981b:100).

The Pathfinder Unit boarded helicopters 15 minutes after the detonation and landed in their objective area. They conducted a radiological reconnaissance to delineate safe landing areas for Task Force WARRIOR participants. Twenty minutes after the detonation, Task Force WARRIOR personnel moved from their observation point to the helicopter loading area in Area 6 and then flew to the intermediate landing zone and waited 15 minutes before flying to the troop landing area (Harris et al. 1981a:30,31,33). The first airlift consisted of 14 H-34 and 8 H-21 helicopters carrying three rifle platoons and a weapons platoon. Harris et al. (1981a:35-37) describes the task force exercise as follows:

> At 0715, the 2nd platoon with an attached 81 mm mortar squad arrived at landing zone (LZ) VICTOR. They secured the high ground (altitude of 5,055 feet) of Objective P4 by 0720. (Objective P4 was 4,100 meters west of SMOKY GZ). At that time, the 2nd platoon prepared for the final ground assault on Objective 2B, a shoulder of Quartzite Ridge.
>
> At 0716, the 3rd platoon landed at LZ ECHO. It secured the high ground (5,303 feet) of Objective P3 by 0740. (Objective P3 was 4,700 meters northwest of SMOKY GZ). At that time, the 3rd platoon prepared for the final ground assault on Objective 2A, the southern end of Quartzite Ridge.
>
> At 0718, the 1st platoon arrived at the airhead. One element landed on the high ground of Objective P2 (5,100 feet), overlooking Whiterock Spring. A second element landed on the high ground of Objective Pl (4,955 feet), which was 1,200 meters to the south. The objectives were secure by 0723. The entire platoon remained at these locations, 5,200 and 5,600 meters west of SMOKY GZ, until exercise termination at 0945.
>
> Two increments of the Weapons Platoon arrived at LZ ECHO. The first increment landed at 0723 and the second increment landed at 0732.
>
> At 0740, these three platoons were in position on the four objectives - P4, P3, P2, and Pl (Figure 2-3).

The second lift carried the remainder of the task force. Seventeen H-34 and eleven H-21 helicopters, including some from the first airlift, participated, leaving the loading area at 0731. Task force activities proceeded as follows:

> At 0740, the Canadian Army Platoon landed at LZ HOTEL, which was 6,000 meters west-northwest of ground zero. At 0800, it occupied Objective QUEEN, about 500 meters to the north, and the reconnaissance and security positions on or near Twin Peaks, 1,000-l, 500 meters to the north (Figure 2-2). [The platoon] remained in these positions, 6,000-6,600 meters northwest of [ground zero] until the exercise was over.
>
> At 0745, the Reconnaissance Platoon, the engineer squad, and the two patrols landed some elements on or near the road west of Whiterock Spring. These units secured the road and occupied two southern reconnaissance security points overlooking the road, 6,500 meters west of [ground zero], until exercise termination (Figure 2-2).
>
> At 0746, the 4th platoon and the medical detachment landed at LZ ECHO. At 0805, the 4th platoon split into two increments to relieve the 3rd platoon on Objective P3 and the 2nd platoon on Objective P4. The relief was complete by 0818. The 4th platoon remained at these positions while the 2nd and 3rd platoons assaulted Objective 2 on Quartzite Ridge.
>
> At 0757, four of the seven aircraft carrying the Mortar Platoon landed at LZ ECHO. The other three helicopters reached ECHO at 0815 after first landing by mistake at HOTEL. By 0826, the mortar platoon was in position.
>
> At 0814, task force headquarters and the communications detachment landed at LZ ECHO. Until exercise termination at 0945, task force operations were controlled from the command post 9 which had been established on the northern side of the landing zone, 5,000 meters from ground zero.
>
> With the exception of the mislanded mortar platoon squads and one aircraft picking up the weapons that platoon soldiers left in the loading area, this landing completed the troop lift.

After the airlift, the ground maneuvers began with the 2nd and 3rd platoons attempting to overtake Objectives 2a and 2b. At the same time, the 4th platoon moved to the reserve assembly area at the ECHO landing zone to replace the 2nd and 3rd platoons. Meanwhile, the 2nd and 3rd platoons had advanced to a point where the radiation levels halted any further movement and capture of the objectives was not accomplished (Harris et al 1981a:37). No further troop movement occurred, however, resupply and evacuation by helicopters had been accomplished during the exercise. Resupply included 27 tons of materials to be distributed by helicopter. All of the supplies except water were sand filled boxes used to simulate the weight of real materials.

Troop-Observer Indoctrination Program

The Troop-Observer Indoctrination Program (Project 50.2) was designed to familiarize military personnel with the effects of nuclear weapons and allow them to view a nuclear detonation (Harris et al. 1981a:38; Harris et al. 1981b:96). The program consisted of official

observers and troops from military units. These included troop, aircraft, and ship commanders; staff officers involved with nuclear weapons and members of fire support units who would use nuclear weapons. Both American and Canadian military observers participated in Smoky. Of the 508 members of the program, 465 were U.S. Army, Navy, Air Force, Marine Corps, Camp Desert Rock personnel, and civilians. The remaining 43 were Canadian observers who were invited to observe the test by the DOD under the Foreign Observer Program (Harris et al. 1981b:97). Project 50.2 included 120 pieces of military equipment to be subjected to the nuclear test. The observers were to occupy trenches prepared for Task Force WARRIOR but due to expected fallout at the trenches, the observers were moved to News Nob.

Technical Service Projects

For the Desert Rock Exercise VII and VIII, projects were undertaken by the Army Technical Services. These projects were to determine the effects of nuclear weapons on Army equipment. For Smoky, the projects were the 1) evaluation of medium range detonation-detection and cloud tracking (Project 50.3), 2) test of ordnance material (Project 50.7), and 3) detection of atomic burst and radioactive fallout (Project 508) (Harris et al. 1981a:40; Harris et al. 1981b:84-85).

Evaluation of Medium Range Detonation-Detection and Cloud Tracking

Project 50.3 was designed to test the Army's capability to evaluate nuclear detonations, to track radioactive clouds, and to test the fallout prediction methods and instruments (Harris et al. 1981a:40). This project was sponsored by the Signal Corps, U.S. Army, and the project report shows that two radar sites provided data for the Smoky test. Originally for the Plumbbob Series, radar was unmanned and no closer that 13 km (8 miles) to ground zero. For Smoky, one radar unit manned by Project 50.3 personnel, was located near Hiko, Nevada, approximately 66 km (41 miles) northwest of ground zero. The other site, Angel's Peak Number 1, approximately 106 km (66 miles) southeast of ground zero and operated by the Air Force as part of the Control and Warning System for Norton Air Force Base, California (Harris et al. 1981a:40). In addition, fallout prediction personnel were located in a mobile van at Mercury, 68 km (42 miles) south of ground zero. Meteorological personnel were located near Alamo, Nevada, situated 105 km (65 miles) to the northeast of the NNSS (Harris et al. 1981a:40).

Test of Ordnance Material

Project 50.7 tested blast, thermal, and radioactive effects of nuclear explosions on ordnance equipment. These tests objectives were to: 1) evaluate the shielding provided by armored vehicles and shielding materials in order to determine the protective value of placing such vehicles and materials over foxholes, 2) examine the effects of neutron radiation on fuses, and 3) collect data on blast damage to armored vehicles (Harris et al. 1981a:41). However at Smoky, Project 50.7 was only concerned with the data on blast damage to armored vehicles while the AFSWP was involved in the other two objectives. At Smoky, two unmanned M-48 tanks were tested. One tank was placed 1,231 feet from ground zero and another was placed in a gully, 2,800 feet from ground zero. The tank closest to ground zero was rolled over onto its top

and suffered extensive damage while the tank furthest from the blast was essentially undamaged (Harris et al. 1981a:41; Harris et al. 1981b:91).

Detection of Atomic Burst and Radioactive Fallout

Project 50.8 was developed to determine how effectively Army units could predict fallout and estimate the yield of nuclear weapons. Secondary objectives included determining the appropriate organization, equipment, and input data necessary to perform these tasks (Harris et al. 1981a:42; Harris et al. 1981b:92). For this project, 557 participants were involved (Harris 1981a:42).

Training Projects

Nuclear testing at the NNSS provided an opportunity to train individuals in the use of various radiological monitoring techniques and how to conduct surveys of radiologically contaminated areas (Harris et al. 1981a:42) . For Smoky, the Army Camp Desert Rock Rad-safe School was in operation (Harris et al. 1981b:100). Desert Rock Rad-safe personnel provided the training and film badging and, in addition, accompanied the Pathfinders into the landing zones during the troop exercises. Pathfinders are specially trained personnel who go into landing areas before the arrival of airlifted or air-dropped units to evaluate selected landing zones and mark appropriate areas so that the incoming pilots can recognize them (Harris et al. 1981a:42).

Support Activities

A variety of types of support troops and personnel were involved at Smoky, e.g., engineers, military police, quartermasters, transportation, and signal companies. Harris et al. (1981a:43-44) outline their participation. The 50th Chemical Platoon provided five motorized, radio-equipped, Rad-safe monitor teams, provided one monitor per Pathfinder helicopter, and operated the field decontamination station near News Nob. The 8th Field Hospital provided five ambulances and medical personnel to administer field medical treatment and to evacuate Camp Desert Rock personnel, observers, and project personnel. The 293rd Military Police Company provided 27 traffic control points and two parking details. The 232nd Signal Company and attached signal teams provided all Desert Rock radio and wire communication services while the 2nd Signal Platoon pictorially documented the before, during, and after-shot activities. The 26th Transportation Battalion provided three vehicle march units which transported personnel to and from Camp Desert Rock and the observer areas.

NEVADA TEST ORGANIZATION

Under Operation Plumbbob, the AEC continued its development of new weapons for delivery to the Armed Forces. Although these programs were carried out mainly by AEC and AEC contractor personnel, DOD personnel assisted, and in addition, carried out many programs of their own. DOD’s interest in Smoky was to perform tests and activities for the national defense program (Harris et al. 1981a:45; Harris et al. 1981b:106). These were the Field Command Weapons Test group that performed extensive experimental work on the military effects of nuclear weapons. The Air Support Group from AFSWC coordinated air sampling, cloud tracking, and air security programs. The Visitors Bureau was a joint AEC/DOD activity

under the AEC Test Manager. DOD personnel participated in both DOD sponsored projects and in projects not sponsored by the DOD, such as those conducted by the AEC and the FCDA (Harris et al. 1981a:45).

AEC and DOD Projects

The following are the military effects programs undertaken at Smoky. Most were AEC programs that were executed by laboratories and contractors such as LANL, SNL, LLNL, and Edgerton, Germeshausen, and Grier Inc. (EG&G), and the CETG.

Armed Forces Special Weapons Project

The AFSWP was responsible for military weapons effects test projects during Smoky. There were nine effects programs and the associated support photography.

Effects of Rough and Sloping Terrain on Airblast Phenomena

Project 1.8 was conducted to investigate blast damage on drag-sensitive targets; determine the nuclear blast effects to targets on rolling, steep slopes, and rough terrain; and provide blast wave measurements. The U.S. Army Ballistic Research Laboratories and Stanford Research Institute was responsible for this project (Harris et al. 1981a:46; Harris et al. 1981b:111). Fifty-one jeeps and two M-48 tanks were placed at various locations around ground zero to investigate blast damage. The remaining two experiments were accomplished by placing gauges along five blast lines.

Spectra of Ground Shocks Produced by Nuclear Detonations

Project 1.9 was to obtain the displacement, velocity, and acceleration-shock spectra of ground shocks produced by nuclear devices (Harris et al. 1981a:48). The data from the ground shocks were used to design missile bases and operational equipment that could be used in a nuclear environment. Three gauges were placed on the ground surface and two in the floor of a German personnel shelter.

Neutron Flux From Selected Nuclear Devices

Project 2.3 was to measure the neutron flux versus ground range for a nuclear device and determine the effect of the terrain on the neutron flux. New weapons of major tactical importance introduced amplified nuclear radiation effects. One such amplified effect, which is of particular importance to land forces, was the generation of neutron induced radiation fields of such intensities as to have a direct influence on tactical ground operations (Harris et al. 1981b:117). The U.S. Army Chemical Warfare Laboratories and the CETG were responsible for the project. Instrumentation was placed on cables along three axes from ground zero: one line south over level terrain, one north over a 152 m (500 ft) hill, and one northeast over hilly terrain. Three hundred detectors were placed at 39 locations on the three cable lines. As soon as 5 minutes after the test, the cables began being pulled out of the high radiation area and the detectors removed from the cables (Harris et al. 1981a:51-52).

Secondary Missiles Generated by Nuclear-Produced Blast Waves

Project 4.3, a DOD and CETG project was to determine the effects of hill-and-dale terrain on the blast-produced missiles (i.e., rocks, wood, etc.). Two stations were set up on flat terrain on the south blast line, three on hills and three in dales on the northeast blast line, and one in a dale on the north blast line. Three traps were set up at each station. Three sizes of spheres (n=405) were 7/16, 1/2, and 9/16 inch diameter. A total of 3,850 pieces of military debris were placed at various distances from the traps (Harris et al. 1981a:52). Hill stations produced missile velocities greater than expected and dale stations produced velocities less than expected. The stations on the flat area produced higher dynamic pressures and higher missile velocities than expected. A total of 2,876 natural stone missiles, 550 pieces of military debris, and all 405 steel spheres were caught in the traps (Harris et al. 1981a:54).

In-flight Structural Response of the FJ-4 Aircraft to a Nuclear Detonation

Project 5.3 was conducted by the U.S. Navy Bureau of Aeronautics and North American Aviation Inc. Three objectives of the program were to measure thermal and blast response of the FJ-4 aircraft to a nuclear explosion, correlate response data with predicted data of the delivery capability of the FJ-4 aircraft, and obtain data to improve predictions for blast response of swept wing aircraft (Harris et al. 1981a:55; Harris et al. 1981b:135). Two planes began the experiment but one was forced to abort because the radar lock-on was lost from the radar van. Four film badges were placed on the aircraft to measure gamma ray dose which was 1.25 rem (post-shot calculation).

In-flight Structural Response of the A4D-1 Aircraft to a Nuclear Detonation

Project 5.4 was conducted by Douglas Aircraft Company. The three objectives of the program were to measure thermal and blast gust response of the A4D-1 to a nuclear detonation, obtain data to improve methods of predicting blast gust response to an aircraft with triangular wings, and to correlate experimental response data with analytical methods to determine the A4D-1 nuclear weapon delivery capability (Harris et al. 1981a:59; Harris et al. 1981b:136). Two planes from Indian Springs Air Force Base were scheduled, but only one was used. The airplane contained five cockpit dosimeters and six cockpit film badges and five dosimeters and four film badges mounted on the outside of the aircraft. The greatest cockpit dose was 1 rem and the greatest outside dose was 1.7 rem.

In-flight Structural Response of the F-89D Aircraft to a Nuclear Detonation

Project 5.5 was conducted by Northrop Aircraft, Inc. and Wright Air Development Center. The primary objective of this project was to determine the structural response of the F-89D aircraft in flight to the blast and thermal effects of a nuclear detonation with a secondary objective of providing data for use in the design of future U.S. Air Force aircraft (Harris et al. 1981a:62; Harris et al. 1981b:136) . This project employed an F-89D aircraft with two crew members. The pilot and observer received no radiation exposure and the plane was not contaminated (Harris et al. 1981a:62)

Accuracy and Reliability of the Short-baseline NAROL System

Project 6.4 was one of five projects under Program 6 conducted in 22 of the 24 Plumbbob events. It was under the direction of the Air Force Cambridge Research Center with the objectives of determining the position and yield of a nuclear detonation, investigate methods of isolating the electromagnetic pulse of a nuclear detonation from lightning transients, and collect data on the nature of bomb pulse distortion from overland propagation (Houghten and Harvey 1958:11; Harris et al 1981a:63; Harris et al 1981b:138-139). The NAROL system is an inverse Loran system and is explained by Houghten and Harvey (1958:12). When a pulse (detonation) is received at two different locations, there is a difference in time for the arrival of the pulse. The pulse at each station is recorded as a hyperbolic line and the intersection of the two lines determines the point of detonation (Narol-fix). The NAROL system nets were 805 km (500 miles) and 1,368 km (850 miles) from the NNSS. No personnel at the NAROL nets received radiation exposures from the Smoky test.

Instrumentation for Measuring Effects Phenomena Inside the Fireball

Project 8.3b was undertaken by the Wright Air Development Center, University of Dayton Research Institute, and Allied Research Associates, Inc. and only active for the Priscilla and Smoky tests (Harris et al. 1981b:142). Its objectives were instrument experiments for making measurements within fireballs; obtaining information on thermonuclear effects of a nuclear detonation; measuring pressure, acceleration, and temperature of a nuclear detonation; and determining velocities by mechanical velocity and distance impact gauges (Harris et al. 1981a:63). At Smoky, 23 specimens were exposed within the fireball and one outside of the fireball. The specimens were attached to cables that extended from the floor of the cab to deadmen anchors in the ground. On August 15, 1957, all specimens or simulating weights were raised into position. Problems were encountered with slippage of the specimens and safety slings were installed to solve the problem. Two days before the test, a zinc sphere was found on the ground and not replaced. After the test, all specimens were recovered by February 1, 1958 (Harris et al. 1981a:67).

Photographic Support

Project 9.1 consisted of photography for military effects programs, military effects motion picture, documentation of the test for the Joint Office of Test Information, and general photographic support for the DOD (Harris et al. 1981a:67). Both color and black-and-white photography were completed from an airborne and forward area manned camera station.

Los Alamos National Laboratory Projects

LANL performed four projects at Smoky. Project 11.1 was radiochemistry analysis and project 11.2 was radiochemistry sampling. Project 11.2 was a joint LANL and LLNL project performed by the AFSWC, 4926th Test Squadron and consisted of cloud sampling. Project 16.2 was temperature measurements and project 17.1 was electromagnetic measurements. Project 16.2 was a joint LANL and EG&G project with instrumentation at the control point and off-site locations.

Lawrence Livermore National Laboratory Projects

LLNL conducted twelve projects at Smoky. Three projects were under Program 21 and were 21.1 radiochemistry analysis; 21.2 radiochemistry sampling; and 21.3 rocket sampling. Four projects were under Program 22 and were 22.1 nuclear radiation measurements; 22.2 remote technique development and telemetry; and 22.4 development experiments. Three projects were under Program 23 and were 23.1 flow and capacity; 23.3 ball of fire and bhangmeter; and 23.4 cloud photography. SNL conducted project 64.2 high time resolution telemetry and project 64.3 neutron sources.

Civil Effects Test Group Projects

CETG projects and the performing agencies are listed in Table 3. These projects were undertaken in conjunction with the DOD, BRL, Amman and Whitney, FCDA, Lovelace Foundation, SNL, Atomic Energy Project/University of California, Las Angeles, Oak Ridge National Laboratory, AFSWP, U.S. Air Force School of Medicine, National Bureau of Standards, Eastman Kodak, AEC, and the AEC Division of Biology and Medicine.

Programs 30, 31, and 34

Programs 30, 31, and 34 were designed to test the mechanical response of structures, materials, and devices to a nuclear blast (Harris et al. 1981b:209). Programs 30 and 31 were to test the performance of structures, structural elements, and devices. Program 34 was designed to test the performance of higher strength materials in higher overpressure regions than Program 31. Projects 30.5, 30.6, 30.7 utilized the 14 French and German underground personnel shelters. The objective was to provide electronic and self-recording instrumentation for shock loading and response measurements for the various structures specifically at Projects 30.6 and 30.7 (Harris et al. 1981a:70). Data from these projects helped in the development of reinforced concrete dome structures, a dual-purpose garage-shelter, a family shelter, and a modular reinforced brick unit (Harris et al. 1981b:210). Devices tested in Programs 30 and 34 were cameras, filters and antiblast valves.

Program 33

Program 33 was concerned with the biomedical effects from a nuclear blast (Harris et al. 1981 b:212). Project 33.2 was designed to determine the size, weight, and velocity of artificial and natural objects propelled by a the blast wave from a nuclear blast (Harris et al. 1981a:70). Project 33.3 was to view the displacement of human-like dummies and spheres from a static to dynamic state from the ground wave produced by a nuclear device.

Program 34

Program 34 was designed to test the strength of reinforcing steel and pipe (Harris et al. 1981a:72). Project 34.2 tested the resistence of rail- and intermediate-grade steel as reinforcement for concrete beams. Project 34.3 tested the resistance of buried corrugated metal pipe to high overpressure.

Table 3. CETG Projects Conducted at Smoky (modified from Harris et al. 1981a:71).

Project	Title	Conducted By	Performing Agency
30.5	Shelter and Structure Blast Instrumentation	Federal Civil Defense Administration	Ballistic Research Laboratory
30.6	Structural Test-French Shelters	Federal Civil Defense Administration/ French Government	Amman and Whitney
30.7	Structural Test-German Shelters	Federal Civil Defense Administration/German Government	Amman and Whitney
31.1	Thermal Activated Air-Zero Locators	Federal Civil Defense Administration	Federal Civil Defense Administration/Nation Bureau of Standards/Kodak
33.2	Missiles Secondary to Nuclear Blast	Atomic Energy Commission Division of Biology and Medicine/Air Force Special Weapons Project-/Federal Civil Defense Administration	Lovelace Foundation
33.3	Displacement Potential of Blast	Atomic Energy Commission Division of Biology and Medicine/Federal Civil Defense Administration	Lovelace Foundation
34.2	Comparison Tests of Reinforcing Steels	Atomic Energy Commission	Sandia National Laboratories
34.3	Comparative Responses of Static and Dynamic Loading	Atomic Energy Commission	Sandia National Laboratories
35.2	Decontamination Procedures in Residential Areas	Federal Civil Defense Administration	Federal Civil Defense Administration
35.3	Radiological Defense Monitoring Techniques	Atomic Energy Commission Division of Biology and Medicine	Federal Civil Defense Administration
36.1	Field Radiological Defense Technical Operations	Federal Civil Defense Administration	Federal Civil Defense Administration
37.1	Biological Accumulation of Fission Products Fallout	Atomic Energy Commission Division of Biology and Medicine	Atomic Energy Project/University of California, Los Angeles

Continued

Table 3. CETG Projects Conducted at Smoky (modified from Harris et al. 1981a:71) (continued).

Project	Title	Conducted By	Performing Agency
37.2	Biophysical Aspects of Fallout Phenomonology	Atomic Energy Commission Division of Biology and Medicine	Atomic Energy Project/University of California, Los Angeles
37.2a	Identification and Documentation-Physical Aspects of Fallout	Atomic Energy Commission	Atomic Energy Project/University of California, Los Angeles
37.4	Measurement of Fast Neutron Doses by Germanium Dosimeters	Atomic Energy Commission Division of Biology and Medicine	Atomic Energy Project/University of California, Los Angeles
37.5	Measurement of Ionizing Radiation by Chemical Methods	Atomic Energy Commission Division of Biology and Medicine	Atomic Energy Project/University of California, Los Angeles
37.6	Application of Radio-Ecological Techniques	Atomic Energy Commission Division of Biology and Medicine	Oak Ridge National Laboratory/Atomic Energy Project/University of California, Los Angeles/Department of Defense
39.1	Gamma and Neutron Radiation Measurements	Atomic Energy Commission Division of Biology and Medicine	Nation Bureau of Standards/Atomic Energy Commission
39.1a	Gamma Dosimetry by Film-Badge Techniques	Atomic Energy Commission Division of Biology and Medicine	Nation Bureau of Standards/Atomic Energy Commission
39.1b	Neutron Dosimetry by the Threshold-Detector Technique	Atomic Energy Commission Division of Biology and Medicine	Nation Bureau of Standards/Atomic Energy Commission
39.5	Radiation Dosimetry for Human Exposures	Atomic Energy Commission Division of Biology and Medicine	Oak Ridge National Laboratory/U.S. Air Force
39.9	Remote Radiological Monitoring	Atomic Energy Commission	Atomic Energy Commission/ U.S. Air Force

Programs 35 and 36

Programs 35 and 36 were designed to answer questions related to civilian radiological defense operations and technologies (Harris et al. 1981b:212). Project 35.2 was to advance the decontamination procedures in residential areas. Project 35.3 was the monitoring of radiation fields and testing radiological instruments.

Program 37

Program 37 was concerned with biological hazards associated with radioactive fallout from nuclear detonations (Harris et al. 1981b:212). The project was divided into the delineation and characterization of fallout patterns; radiological, physical, and chemical properties of fallout debris within the fallout patterns; and the evaluation of biological availability and accumulation of radionuclides in plants and animals. Project 37.2 and 37.2a were concerned with the delineation and characterization of fallout patterns during the test and analysis of certain specific fission products conducted by the Atomic Energy Project, University of California, Los Angeles (Harris et al. 1981a:72).

Project 39

Project 39 projects used outside instrumentation and support services from various CETG programs. Project 39.1 utilized film dosimetry techniques for the measurements of gamma radiation. Film dosimeters were placed at 91 m (300 ft) intervals from 457 m (1,500 ft) though 1,372 m (4500 ft) from ground zero. Project 39.1a was to gather adequate radiation measurements by measuring gamma dose points at various locations. Project 39.1b was to provide neutron dose measurements. Project 39.5 was to study the angular distribution of fast neutron and gamma rays to determine the shielding properties from light frame houses (for Smoky, 120 collimators and 36 sets of goal posts were used). Project 39.9 measured radiation from onsite and offsite locations by telemetering techniques (Harris et al. 1981a:74).

Air Training Projects

The aircraft were to be flown from the Indian Springs Air Force Base and other staging areas. Project 51.3 was conducted by the U.S. Navy to provide AJ and A3D combat aircraft crews with the opportunity to observe an atomic detonation in the near vicinity of burst (Harris et al. 1981a:74). At Smoky, three F9F-3 aircraft were substituted for the AJ2 and A3D aircraft. The aircraft would fly a simulated bomb run and then perform an escape maneuver to arrive 8 km (5 miles) from ground zero heading 180 degrees at the time of detonation. Because of conflicting documentation, it is unsure if these planes flew the mission (Harris et al. 1981a:75).

Project 51.3

For the Project 51.3 , four T-33 aircraft were flown by Air National Guard pilots to collect samples for radiochemical analysis.

Project 53.5

Project 53.5 was to provide an opportunity for Air Defense Command aircrew members and aircraft commanders to observe an atomic detonation in the area of the burst and penetrate the nuclear cloud (Harris et al. 1981a:75). Five T-33 aircraft were to participate but the project was discontinued before the Smoky test.

Project 53.7

Project 53.7 evaluated Indirect Bomb Damage Assessment equipment installed in an F89H aircraft. The aircraft was 165 km (89 nautical miles) from the burst and did not fly though the nuclear cloud (Harris et al. 1981a:75).

Project 53.8

Project 53.8 was to test the suitability of the Indirect Bomb Damage Assessment equipment and techniques under a simulated bomb drop and burst conditions (Harris et al. 1981a:76). The aircraft was 65 km (35 nautical miles) from ground zero at the time of detonation and did not fly through the nuclear cloud.

Project 53.9

Project 53.9 was to provide photographic training of Air National Guard Tactical Crews during a nuclear detonation. Two RF84F aircraft from the Tennessee Air National Guard were staged at George Air Force Base, California. The planes flew over ground zero before the detonation at 6,096 m (20,000 ft) to 9,144 m (30,000 ft). At 10 minutes after the detonation, the planes flew under the mushroom cloud at 914 m (3,000 ft) to 1,219 m (4,000 ft) at 440 knots (506 miles per hour) and made one photo-reconnaissance pass (Harris et al. 1981a:76). When the plane returned to George Air Force Base, it taxied to a remote area to be checked for contamination. Harris et al. (1981a:76) does not indicate the airplanes' condition and states that no records of badging of the pilots exist. However, one pilot was interviewed and stated that they wore DT-60 dosimeters which would not record low levels of radiation.

Cloud Sampling and Tracking

Cloud sampling at Smoky was undertaken by the U.S. Air Force and elements of 14 Air National Guard units (Harris et al. 1981a:78). Flights at 4,572 m (15,000 ft) by a B-25 and 7,315 m (24,000 ft) by a B-29 were flown dependant on the configuration of the detonation and winds. The planes flew to the nuclear cloud and turned away when readings between 5 and 10 m/Rh were encountered.

Joint AEC/DOD Visitors

The FCDA invited 67 official visitors and 42 new media personnel to observe the Smoky test from near News Nob (Harris et al. 1981a:79). An additional 24 news media personnel accompanied the First Battle Group troops.

Program 22

Program 22 was conducted by the UCRL and included four projects at Smoky: nuclear radiation measurements (Project 22.1), remote technique development (Project 22.2), telemetry (Project 22.3), and developmental experiments (Project 22.4) (Johnson 1957; Harris et al. 1981a). In the Instrument Chart for Operation Plumbbob (DOE 1957), four stations in the Smoky test area are listed for Program 22. These are a cokehill (8-22-6001), a cokehill fluor and convertor (8-22-6002), a fluor on a concrete pad (8-22-6003), and a wood platform with test panels (8-22-6004). Remote stations used for Program 22 are the optical addition to the Area 2-300 bunker and turning mirrors for the cokehill and cokehill fluor approximately 4.5 km (2.6 miles) southwest of the Smoky ground zero.

Standard diagnostics for atmospheric tower tests required running coaxial cable beneath the surface to a nearby recording bunker. At Smoky, because of the distance between the tower in Area 8 and the recording bunker in Area 2 standard diagnostics were not possible and Program 22 experiments were done photographically or remotely. One objective of the Program 22 diagnostic experiments was to measure alpha radiation by observing fluor arrays photographically. Fluor is any of a class of minerals that are soft, readily fusible, and useful in smelting. Fluor is utilized as part of a process to detect the amount of radioactivity present in the air. Specific types of radioactive particles can interact with electrons, producing an excited state. Excitation energy in electrons can be transferred to fluor molecules, de-exciting them and allowing the energy to be detected and measured (Wouters 1955). Nuclear detonations produce ultraviolet energy that is not visible and, therefore, unmeasurable with photo electronic devices. Converter compounds can be introduced during the process and can absorb ultraviolet energy and re-emit it at a longer wave length, making it more visible to be recorded (Wouters 1955). However, at Smoky the fluor experiment failed probably due to camera misalignment possibly caused by a high explosive detonation in Area 4 just prior to the test (Johnson 1957).

Project Not Associated With the Smoky Test

In the CA south of the Smoky ground zero are two military personnel carriers and an airplane. Many have assumed that the personnel carriers and airplane were used during the Smoky test. However, the two tanks used during the Smoky test were M-48s and not personnel carriers (Harris et al. 1981a:41). The two personnel carriers are not related to the Smoky test but were part of the Plutonium Training Program undertaken in Areas 8 and 11. The F-47 Thunderbolt was a part of the Tumbler-Snapper test series of atmospheric nuclear test; Project 3.1 (Vulnerability of Parked Aircraft to Atomic Bombs); tests Able, Baker, Charlie, and Dog (Schraut and Breidenbach 1953:55-56; Ponton et al. 1982:87). The airplane was moved to near Yucca Lake after the tests and then to its present position in the 1960s for the Plutonium Training Program. As such, it was not related to the Smoky test. However, this is the only known airplane used in nuclear testing left at the NNSS. The airplane probably is a significant cultural property for its association with the Tumbler-Snapper tests Baker, Charlie, and Dog and as a part of the Plutonium Training Program. The airplane and personnel carriers are outside of the inventoried area for this project and were not recorded during this project.

Continuing Studies

Stimulated by reports of the excess incidence of leukemia among veterans who had participated at the Smoky test in 1957, a study of mortality, by cause of death, was done on approximately 46,000 participants in one or more of five test series (Robinette et al. 1985). The series studied were Upshot-Knothole (1953) and Plumbbob (1957) at the NNSS, and Greenhouse (1951), Castle (1954), and Redwing (1956) conducted at the Pacific Proving Ground at Enewetak and Bikini islands. The participants were traced individually by the use of Veterans Administration records. Mortality from leukemia among the participants at Smoky were 2.5 times the expected number (Robinette et al. 1985).

Since then, the Medical Follow-up Agency of the National Research Council has maintained a program in the interest of medical research into this area of nuclear testing. On January 15, 1994, President Bill Clinton formed the Advisory Committee on Human Radiation Experiments (ACHRE). ACHRE's final report was a factor in the Department of Energy establishing an Office of Human Radiation Experiments that assured publication of DOE's involvement (by way of its predecessor, the Atomic Energy Commission) in Cold War radiation research and experimentation on human subjects.

RESEARCH QUESTIONS AND DATA REQUIREMENTS

The Smoky project focuses on the area surrounding an atmospheric nuclear test ground zero and it is expected the historic resources in the project area will be associated with the 1957 Smoky test. Previous cultural resource inventories in the general area have revealed a small number of isolated prehistoric artifacts and a few Cold War era historic remains. It is feasible the Smoky test area might have contained some prehistoric and pre-Cold War historic materials prior to its use as a nuclear test bed. However, as a result of the construction of the test area and the detonation of a nuclear device, it is unlikely earlier cultural resources survived the test. If so, they would lack depositional integrity.

- What is the history of atmospheric nuclear testing facilities at the location?

  Data requirements - Archival research provides a historic context for atmospheric test locations. Detailed recording of the cultural material remains of the test facilities would be a source of ancillary supporting data for the information derived from historic sources. A comprehensive record of the test area including archival information and testing remains on the post-test landscape would provide a complete record of the history of an atmospheric nuclear test.

- What is the structure of an atmospheric nuclear test site and how does the condition and spatial distribution of post-test remains compare to this pre-test setup?

  Data requirements – To address the question, the cultural materials would need to provide a relatively complete picture of the testing landscape. Historic records and engineering drawings provide locations and descriptions of the atmospheric test site plan. However, little is documented about the spatial distribution and physical condition of these resources on the post-test landscape. These resources need to have a high degree of integrity and potential to contribute information beyond what is already available in the historic record. Integrity would be evaluated based on post-test condition, i.e., areas that

did not undergo extensive post-test remediation and clean-up and are relatively unmodified and undisturbed following the test would retain integrity.

- What is the scientific significance of the nuclear testing remains in the area?

  Data Requirements – A test area containing remains from a nuclear test and post-test integrity would potentially provide scientific evidence for future nuclear scientists regarding the intricacies of a nuclear blast. Scientists at LANL and LLNL continue to study data from decades old tests in order to better understand the underlying nature of the nuclear explosions. The data requirements for this question require cultural materials not be modified or disturbed.

CULTURAL RESOURCES

The Smoky historic district, designated D104, possesses a significant concentration of resources united historically by the engineering plan for the Smoky atmospheric test as well as post-test features and artifacts. D104 shares a footprint with two spatially discrete historic archaeological sites, the Smoky test area (26NY14794) and the Smoky military trenches (26NY14795). The historic archaeological sites are related by association with the Smoky nuclear test, but are separated geographically and, therefore, D104 is discontiguous (see Figures 3 and 4).

The focal point of D104 and site 26NY14794 is ground zero for the test (Figure 43). Of the 1,308 artifacts recorded during this study over 90 percent are within 122 m (400 ft) of ground zero, the close-in area for the nuclear test (Figure 44). Most artifacts are remains from the T-2c tower (tower legs, tensioning rods, etc.), lead bricks used to shield instrumentation during the test, and miscellaneous cable. The T-2c tower was destroyed during the nuclear test; however, a series of engineered elements of the tower remain. These are the foundation (S887), elevator pit (S888), elevator hoist pad (S889), and seven of the original 12 stanchion pairs (S893, S894, S895, S896, S897, S898, and S904) used to anchor guy wire to stabilize the 700 ft tower. When evaluated together these tower elements contribute to the significance of D104. Additional structures associated with the tower are concrete pads and cable anchors used for a cable system to secure instruments for a variety of experiments (S890 and S899). Instrument stations for diagnostic and scientific studies were also recorded in the Smoky test area. These are a series of three structures used for nuclear radiation measurements and remote measuring techniques (S891, S892, and S921), an underground station (the precise purpose is unknown) (S900), the underground Ballistic Research Laboratory (S919), a station with stands for blast wave gauges (S920), a concrete pad with attachments for instrumentation (S902), and a battery vault (S903). Underground personnel shelters designed by the French and Germans are southeast of ground zero. As these were made with reinforced concrete, they remain in excellent condition. The five French shelters (S906, S907, S908, S909, and S910) and eight of the nine German shelters (S911, S912, S913, S914, S915, S916, S917, and S918) were recorded. These are from 256 m (840 ft) to 740 m (2,430 ft) southeast of ground zero along an established blast line with the French shelters west of the line and the German shelters east. An emergency exit shaft and vent stack (S923) was originally thought to be part of an additional structure, but is attached beneath the surface to S918, a German shelter. A trailer in ruins (B12411), electrical panel and backboard (S901), and electrical switch boxes and backboard (S905) were recorded. However, these are not associated with the Smoky test and are not contributing resources to D104.

Site 26NY14795 encompasses the area of a series of seven military trenches (S922) 4.3 km (2.7 miles) southeast of the ground zero. The trenches were to be used for troop exercises. However, due to unfavorable wind forecasts and fallout projections the trenches were not occupied during the Smoky test. Trenches are easily visible on aerial images (Figure 45) and in the field and were recorded as S922. No artifacts were recorded in the trench area. However, cultural materials possibly are buried in the partially filled trenches.

In the following discussion, recorded cultural resources are described in two sections, the Smoky test area (D104 and 26NY14794) and the military trenches (D104 and 26NY14795).

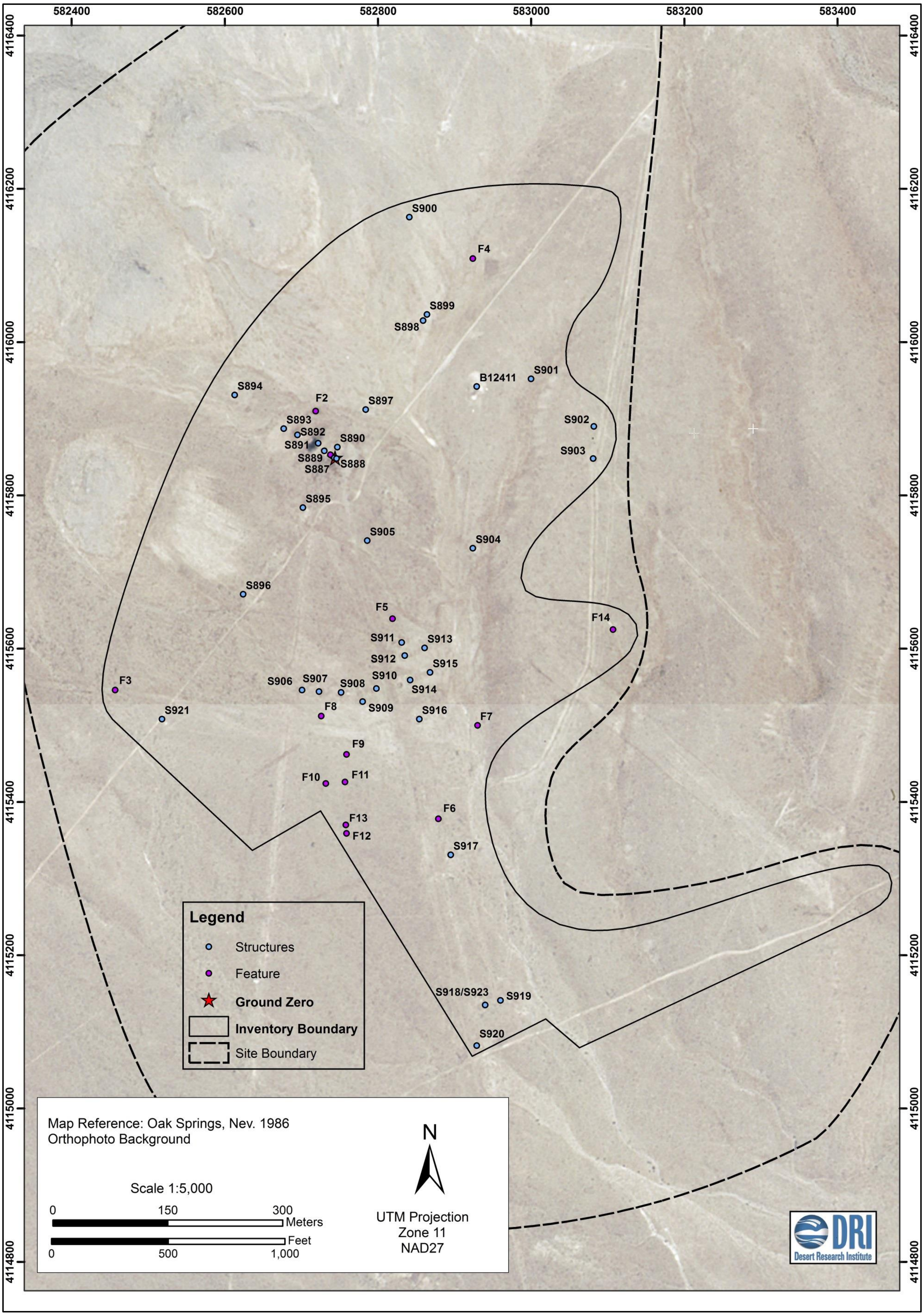


Figure 43. Structures and features in the site 26NY14794 inventory area of the Smoky project.

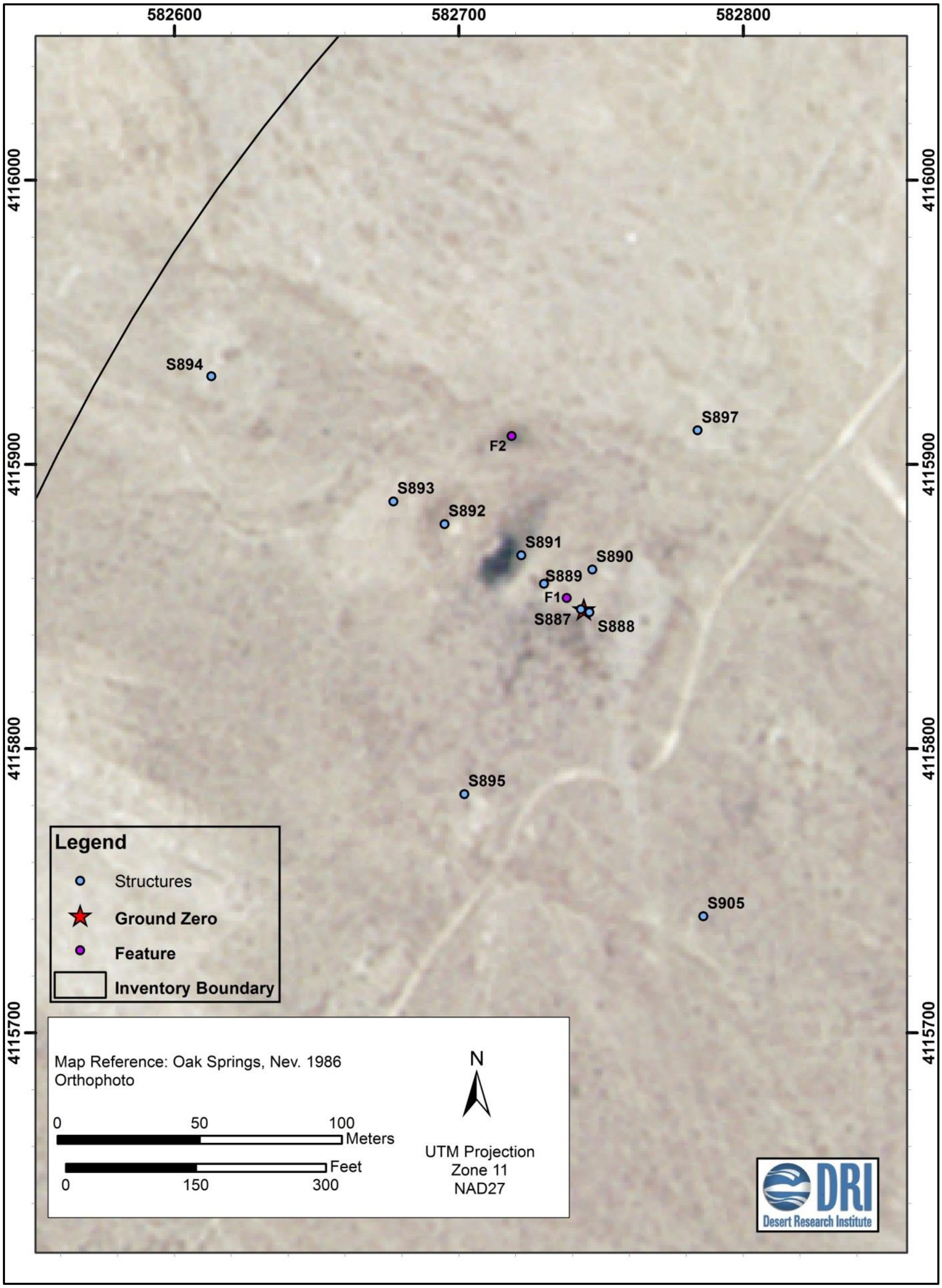


Figure 44. Close-up of structures and features near the Smoky ground zero.

Figure 45. Military trenches (S922) in the 26NY14795 survey area of the Smoky project.

SMOKY TEST AREA (D104 and 26NY14794)

ARTIFACTS

A total of 1,308 artifacts were recorded (Table 4). Of these, 1,262 artifacts are from the ground zero area. Ground zero artifacts mainly consist of layers of twisted, broken, and melted metal structural elements of the Smoky tower and elevator assembly. Components of the tower and elevator include structural round and square metal tower legs and tension rods, elevator hoist drum and reducer gears, and metal fragments (Figures 46-56). Other materials associated with the test are spread throughout the ground zero concentration and include charcoal briquettes, wood fragments, partially melted lead bricks, and fragments of glass (Figures 57-59). Artifacts near the underground personnel shelters total 19 and include pieces of the tower (box beams, I-beams, round tensioning rods or diagonal braces, and metal fragments), as well as pieces of rebar reinforced concrete and batteries. Recorded artifacts in the remaining areas of the site total 27 and include tower box beams, round tensioning rods, diagonal braces, cable fragments, a pipe with footing, metal fragments, glass, and wood fragments. Structural components (box beams and diagonal braces) of the Smoky tower are found as far away as 908 m (2,979 ft) from ground zero.

Table 4. Artifacts Recorded at 26NY14794.

Ground Zero Area			
Material	**Artifact Type**	**Count**	**Description**
Glass	Fragment	4	Fragments of green glass
Metal	Angle iron	3	Pieces range from 30.5 cm to 91.4 cm in length
	Armature	1	Armature for elevator hoist drum motor
	Cable	27	Vary in length and size, maximum diameter of 6.4 cm
	Drum gear	1	Elevator hoist drum gear, 1.7 m in diameter and 14 cm thick
	Fragment	698	Generally pieces of box beams and framing beams less than 2.54 cm to 30.5 cm
	Framing platform/ elevator box beam	23	Square box beams for framing platforms and the elevator assembly, 10.16 cm square and up to 6.1 m in length.
	Gear reducer	1	Gear reducer for elevator hoist system
	Hoist drum	1	Elevator hoist drum
	I-beam	8	Used in tower framing platforms and the elevator assembly, 10.16 cm and 20.32 cm in width and up to 6.1 m in length
	Lead bricks	287	20.3 x 7.6 x 5.0 cm
	Pedestal base	1	Pedestal base for elevator hoist, trapezoidal shape 1.29 m long at the bottom, 67 cm long at the top, 66 cm tall, and 25 cm thick
	Pins	9	Pins for clevis at the end of tensioning rods, 6.35 cm in diameter
	Round tensioning rod	111	4.44 cm in diameter and up to 4.1 m in length
	Tower leg (round)	31	22.3 cm diameter round pipe up to a maximum length of 7.62 m
	Tower leg base	10	Square steel plates 61 x 61 cm and 40.6 x 40.6 cm and up to 30.4 x 30.4 cm for the framing beams
	Tower leg box beam	30	Square box beams 22.3 cm square, 2.9 cm and 2.22 cm in thickness, and up to 7.62 m in length
	Wire	1	Insulated and non-insulated types
Wood	Fragment	15	2-x-4s, 4-x-4s, and plywood
Subtotal		**1,262**	

Table 4. Artifacts Recorded at 26NY14794 (continued).

Underground Personnel Shelter Area			
Metal	Battery	3	Lead acid automobile batteries
	I-beam	1	Used in tower framing platforms and the elevator assembly, 10.16 cm and 20.32 cm in width and up to 6.1 m in length
	Metal fragment	6	Pieces of box beams and framing beams less than 2.54 cm to 30.5 cm
	Round tensioning rod or diagonal brace	5	4.44 cm in diameter and up to 4.1 m in length
	Tower leg box beam	3	22.3 cm square, 2.9 cm and 2.22 cm in thickness, and up to 7.62 m in length
Reinforced concrete	Fragment	1	Unknown block of concrete with rebar
Subtotal		**19**	
Remaining Area			
Material	**Artifact Type**	**Count**	**Description**
Glass	Container	1	Hollow based clear glass container with aluminum foil (possibly experiment container)
Metal	Cable fragment	6	Vary in diameter and length
	Fragment	3	Pieces of box beams and framing beams less than 2.54 cm to 30.5 cm
	Light shade	1	Aluminum light shade - crushed
	Pipe with footing	1	22.9 cm in diameter and 2.5 m in length
	Round tensioning rod or diagonal brace	10	4.44 cm in diameter and up to 4.1 m in length
	Tower leg box beam	3	Square box beams, 22.3 cm square, 2.9 cm and 2.22 cm in thickness, and up to 7.62 m in length
Wood	Fragment	2	Plywood fragments
Subtotal		**27**	
Grand Total		**1,308**	

Figure 46. Square beam box leg, view northeast (2012).


Figure 47. Round tower leg, view southeast (2012).


Figure 48. Base for tower beam, view north (2012).


Figure 49. Box beam for framing, view east (2012).


Figure 50. Guy cables, view northeast (2012).

Figure 51. Close-up of tensioning rod (2012).


Figure 52. Pin for tensioning rod, view east (2012).

Figure 53. Hoist drum, view west (2012).

Figure 54. Pedestal base for hoist, view northeast (2012).

Figure 55. Gear reducer for hoist, view northwest (2012).

Figure 56. Drum gear for hoist, view northwest (2012).

Figure 57. Green glass, view northwest (2012).

Figure 58. Lead bricks, view northeast (2012).

Figure 59. Close-up of lead bricks (2012).

FEATURES

Fourteen features were recorded. Of these, two features are in the ground zero area: a set of concrete blocks (Feature 1) and a charcoal briquette concentration (Feature 2). Features near the underground personnel shelter area are a concrete pad (Feature 5), a cable spool stand (Feature 6), a series of tangled and bent metal bars (Feature 7), and six concrete vent sections from the personnel shelters (Features 8 through 13). Other features within the Smoky test area are a collapsed plywood box (Feature 3) 415 m (1,361 ft) southwest of ground zero, a water heater (Feature 4) 314 m (1,030 ft) northeast of ground zero, and a concentration of engine parts and a metal grate (Feature 14) 445 m (1,460 ft) east of ground zero. These three features are not associated with the Smoky test and are non-contributing resources to D104.

Table 5. Features Recorded at 26NY14794.

ID Number	Description	Contributing to D104	UTM (Zone 11 NAD27)	
			Easting	Northing
Feature 1	Concrete blocks	Yes	582738	4115853
Feature 2	Charcoal briquette concentration	Yes	582718	4115910
Feature 3	Plywood box	No	582457	4115546
Feature 4	Water heater	No	582924	4116109
Feature 5	Concrete pad	Yes	582819	4115639
Feature 6	Cable spool stand	Yes	582879	4115378
Feature 7	Series of bent metal bars	Yes	582930	4115500
Feature 8	Concrete vent section	Yes	582726	4115512
Feature 9	Concrete vent section	Yes	582759	4115462
Feature 10	Concrete vent section	Yes	582732	4115424
Feature 11	Concrete vent section	Yes	582757	4115426
Feature 12	Concrete vent section	Yes	582758	4115370
Feature 13	Concrete vent section	Yes	582759	4115359
Feature 14	Engine parts and a metal grate	No	583107	4115625

Feature 1 – Concrete Blocks

Feature 1 consists of two rectangular, rebar-reinforced concrete blocks that are 3 m (9 ft 10 inches) apart, and a third concrete block fragment between the blocks (Figure 60). The centerpoint of the three blocks is at UTM coordinate 582738 E, 4115853 N (Zone 11 NAD27). The blocks are located 9.8 m (32 ft) southeast of S889, a hoist pad in the ground zero area. The northern block is 1.9 m (6 ft 1 1/4 inches) long by 25.4 cm (10 inches) wide. The southern block is 2.1 m (6 ft 10 inches) long by 25.4 cm (10 inches) wide. The block fragment is 1.9 m (6 ft 1 1/4 inch) long by 25.4 cm (10 inches) wide. The blocks are partially buried and thickness of the

blocks was not determined. No attachments (bolts, metal plates, etc.) are present on the concrete blocks. All three blocks are broken and deteriorated (Figure 60).

Feature 2 – Charcoal Briquette Concentration

Feature 2 consists of a charcoal briquette concentration. The center point of the concentration is at UTM coordinate 582718 E, 4115910 N (Zone 11 NAD27) (Figure 61). The concentration is along the edge of an interfluve that slopes gradually to the east. The concentration measures 8.1 m long (26 ft 7 inches) by 5 m wide (16 ft 5 inches). A diffuse scatter of charcoal briquettes extends west of the concentration for approximately 108 m (354 ft) and south-southwest for approximately 85 m (279 ft). Feature 2 probably acted as a staging area for charcoal briquettes for the cokehill component of S891, located 11 m (36 ft) to the south. The briquettes were probably dispersed during the Smoky nuclear blast.

Feature 3 – Plywood Box

Feature 3 is a collapsed, rectangular wood box made of 3/4-inch plywood (Figure 62). It is at UTM coordinate 582457 E, 4115546 N (Zone 11 NAD27) and is 71 m (233 ft) north of S921, fluor on a concrete pad. The bottom of the plywood box is 1.5 m (5 ft) long by 0.86 m (2 ft 10 inches) wide. The height of the box is roughly 1 m (3 ft 4 inches). On the bottom of the box are attached two 2-x-4 runners.

Feature 4 –Water Heater

Feature 4 is a water heater made of a steel cylinder within a rusted, rectangular metal frame (Figure 63). It is at UTM coordinate 582924 E, 4116109 N (Zone 11 NAD27) and is 90 m (295 ft) northeast of S899, two instrumentation cable anchor pads. The frame is 40.6 cm x 0.6 cm x 82.6 cm (1 ft 4 inches x 1/4 inch x 2 ft 10 1/2 inches). Brass connections extend from the cylinder through the metal frame.

Feature 5 – Concrete Pad

Feature 5 is a rough-finished, square concrete pad (Figure 64). It is at UTM coordinate 582819 E, 4115639 N (Zone 11 NAD27) and is 30 m (98 ft) north of S911, German personnel shelter RAa, and 222 m (728 ft) south of Smoky ground zero. The concrete pad measures 1.52 m x 1.52 m (5 ft x 5 ft). Two 2-x-4s frame the concrete pad on the east and west sides. There are no attachments (bolts, metal plates, etc.) present on the concrete. The edges and corners are deteriorating.

Feature 6 – Cable Spool Stand

Feature 6 is an iron cable spool stand with an attached brake handle (Figures 65-66). It is at UTM coordinate 582879 E, 4115378 N (Zone 11 NAD27) and is 44 m (144 ft) north of S917, German personnel shelter RCa. The stand is constructed of 15.2 cm (6 inches) wide channel iron and a 15.2 cm (6 inches) wide angle iron. The base is 2.84 m x 2.84 m (9 ft 4 inches x 9 ft 4 inches) and the cable spool support legs are 1.98 m (6 ft 6 inches) in height and notched at the

top. The legs are braced with diagonal 15.2 cm (6 inches) angle iron supports. A brake handle is on the west leg of the stand and consists of a fiber-lined metal strap and a metal handle. The brake handle is 1.5 m (5 ft) in length and is disconnected from one end of the fiber-lined metal strap, which may contain asbestos.

Feature 7 – Series of Bent Metal Bars

Feature 7 consists of a series of tangled metal bars of various lengths (Figure 67). The centerpoint of this feature is at UTM coordinate 582930 E, 4115500 N (Zone 11 NAD27) and is 70 m (230 ft) west of S916, German personnel shelter RAd. All the metal bars are 1.27 cm (1/2 inch) in diameter with one end bent at a 180 degrees angle to form a hook and at least one 90 degree bend along their lengths. Some of the bent metal bars are partially buried. No clearly defined pattern can be distinguished.

Features 8-13 – Concrete Vent Sections

According to Cohen and Dobbs (1962), intake and exhaust shafts extending above surface grade were broken off by the Smoky blast-wave at three of the French underground personnel shelters. During field recording, missing vent sections from these shelters (S907, S908, and S909) were noted and nearby vent sections lying on the surface, one for each structure, were recorded as part of the structure. Six additional vent sections were recorded as features. These are distributed in a linear pattern commensurate with the blast line and up to 183 m (600 ft) south of their original locations (Figure 43). The six concrete vent section features are described below.

Feature 8 – Concrete Vent Section

This feature is an upright, rectangular section of a smooth-finished, rebar-reinforced concrete vent from a French underground personnel shelter (Figure 68). It is at UTM coordinate 582726 E, 4115512 N (Zone 11 NAD27) and is 30 m (98 ft 3 inches) south of S907, French personnel shelter II-3. The vent measures 0.6 m x 0.6 m x 1.24 m (2 ft x 2 ft x 4 ft 1 inch) and has a 22.9 cm (9 inches) diameter pipe extending through the center of the concrete. Rebar extends from the broken top edge of the concrete.

Feature 9 – Concrete Vent Section

This feature is an upright, rectangular section of a rough-finished, rebar-reinforced concrete vent from a French underground personnel shelter (Figure 69). It is at UTM coordinate 582759 E, 4115462 N (Zone 11 NAD27) and is 65 m (213 ft) south of S909, French personnel shelter II-5. It measures 0.6 m x 0.6 m x 0.6 m (2 ft x 2 ft x 2 ft). The metal pipe is absent from the center of the concrete leaving a 22.9 cm (9 inches) diameter hole through the center of the concrete. Rebar extends from the broken top edge of the concrete.

Feature 10 – Concrete Vent Section

This feature is a rectangular section of a rough-finished, rebar-reinforced concrete vent from a French underground personnel shelter (Figure 70). It is at UTM coordinate 582732 E, 4115424 N (Zone 11 NAD27) and is 110 m (360 ft) south of S909, French personnel shelter II-5. It measures 0.6 m x 0.6 m x 0.9 m (2 ft x 2 ft x 3 ft) and has a 22.9 cm (9 inches) diameter pipe extending through the center of the concrete. The pipe is crushed on its end. Rebar extends from the broken ends of the concrete.

Feature 11 – Concrete Vent Section

This feature is an upright, rectangular section of a smooth-finished, rebar-reinforced concrete vent from a French underground personnel shelter (Figure 71). It is at UTM coordinate 582757 E, 4115426 N (Zone 11 NAD27) and is 100 m (382 ft) south of S909, French personnel shelter II-5. It measures 0.6 m x 0.6 m x 0.48 m (2 ft x 2 ft x 1 ft 7 inches). The metal pipe is absent from the center of the concrete leaving a 22.9 cm (9 inches) diameter hole through the center of the concrete. Rebar extends from the broken top edge of the concrete.

Feature 12 – Concrete Vent Section

This feature is an upright, rectangular section of a rough-finished, rebar-reinforced concrete vent from a French underground personnel shelter (Figure 72). It is at UTM coordinate 582758 E, 4115370 N (Zone 11 NAD27) and is 100 m (382 ft) south of S909, French personnel shelter II-5. It measures 0.6 m x 0.6 m x 0.5 m (2 ft x 2 ft x 1 ft 8 inches). The metal pipe is absent from the center of the concrete leaving a 22.9 cm (9 inches) diameter hole through the center of the concrete. Rebar extends from the broken top edge of the concrete.

Feature 13 – Concrete Vent Section

This feature is a rectangular section of a rough-finished, rebar-reinforced concrete vent from a French underground personnel shelter (Figure 73). It is at UTM coordinate 582759 E, 4115359 N (Zone 11 NAD27) and is 170 m (557 ft) south of S909, French personnel shelter II-5. The vent measures 0.6 m x 0.6 m x 1.47 m (2 ft x 2 ft x 4 ft 10 inches) and has a 22.9 cm (9 inches) diameter pipe extending through the center of the concrete, which is bent at a 90 degree angle on one end. Rebar extends from the broken top edge of the concrete.

Feature 14 – Engine Parts and a Metal Grate

This feature consists of an engine starter, a pump, a rectangular battery box and lid, and a square, yellow spray-painted metal grate (Figure 74). The center point of this concentration is at UTM coordinate 583107 E, 4115625 N (Zone 11 NAD27). The battery box has a lead brick inside that measures 20.3 cm x 7.6 cm x 5.0 cm (8 inches x 3 inches x 2 inches). The yellow metal grate measures 0.7 m (2 ft 4 inches) long by 0.6 m (2 ft) wide. The engine starter is partially buried in alluvium while the others sit on the surface.


Figure 60. Feature 1, concrete blocks, view northeast (2012).

Figure 61. Feature 2, charcoal briquette concentration, view east (2012).

Figure 62. Feature 3, plywood box, view southwest (2012).

Figure 63. Feature 4, water heater, view southwest (2012).


Figure 64. Feature 5, concrete pad, view west (2012).


Figure 65. Feature 6, cable spool stand, view east (2012).


Figure 66. Feature 6, close-up of brake handle, view east (2012).

Figure 67. Feature 7, bent metal rods, view northeast (2012).

Figure 68. Feature 8, concrete vent section, view northeast (2012).

Figure 69. Feature 9, concrete vent section, view southeast (2012).

Figure 70. Feature 10, concrete vent section, view southwest (2012).

Figure 71. Feature 11, concrete vent section, view west (2012).

Figure 72. Feature 12, concrete vent section, view southwest (2012).


Figure 73. Feature 13, concrete vent section, view east (2012).

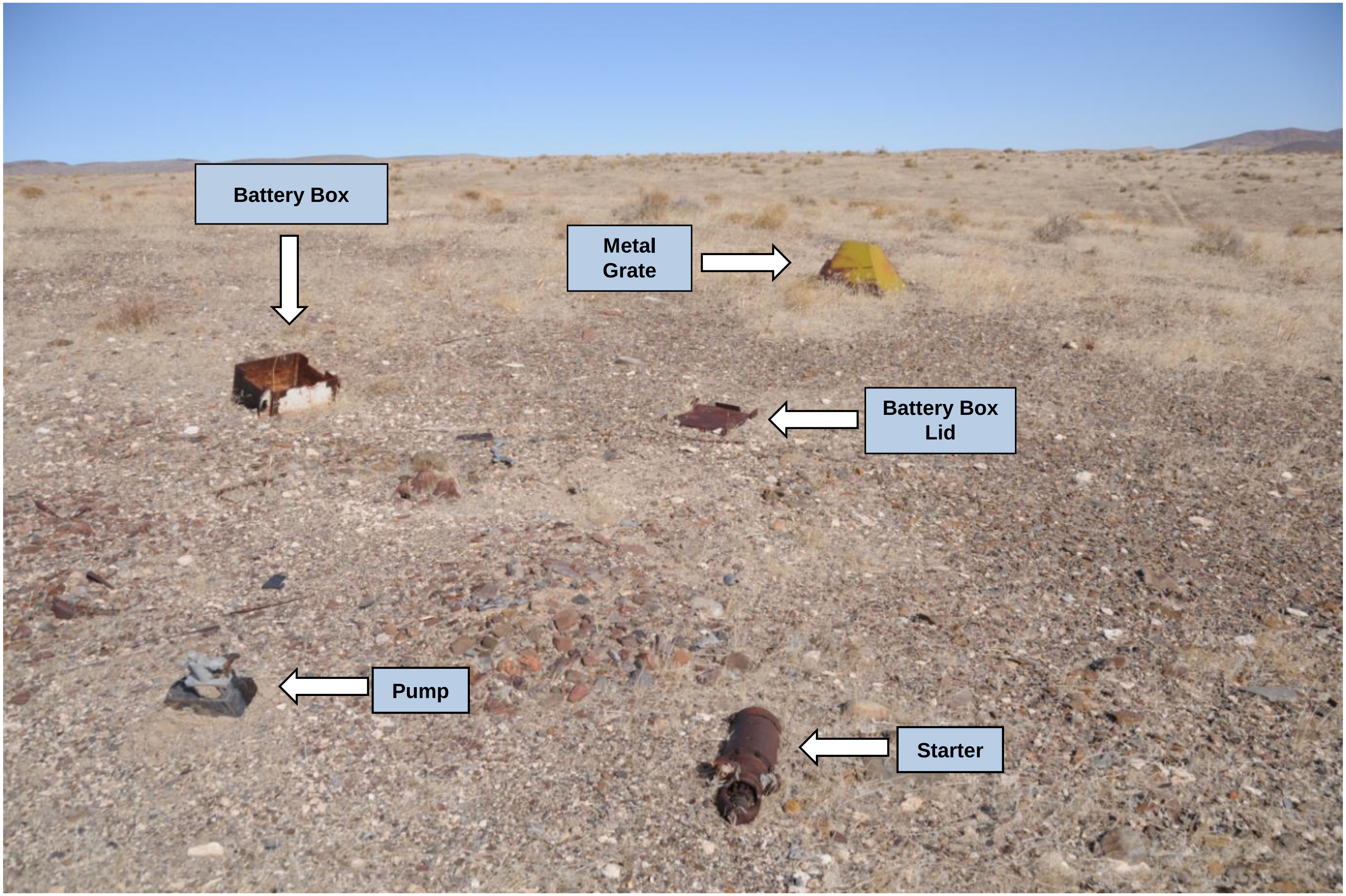


Figure 74. Feature 14, concentration of engine parts and a metal grate, view northeast (2012).

BUILDINGS AND STRUCTURES

Within the inventoried Smoky test area (26NY14794), DRI recorded 1 building (a trailer not associated with the Smoky test) and 36 structures (Table 6). Of the 36 structures, 34 contribute to the significance of D104. These are the remaining elements of the tower (tower foundation, stanchions, elevator pit, and hoist foundation), instrument stations, and underground personnel shelters.

Table 6. Building and Structures Recorded within 26NY14794.

SHPO Resource #	Description	Contributing to D104	UTM (Zone 11 NAD27)	
			Easting	Northing
B12411	Trailer	No	582929	4115942
S887	T-2c tower foundation	Yes	582743	4115849
S888	Elevator pit	Yes	582746	4115848
S889	Elevator hoist pad	Yes	582730	4115858
S890	Anchor block with attachments	Yes	582747	4115863
S891	Station 8-22-6001,Cokehill	Yes	582722	4115868
S892	Station-8-22-6002 Fluor and convertor for the Cokehill	Yes	582695	4115879
S893	Stanchion pair northwest of GZ	Yes	582677	4115887
S894	Stanchion pair northwest of GZ	Yes	582613	4115931
S895	Stanchion pair southwest of GZ	Yes	582702	4115784
S896	Stanchion pair southwest of GZ	Yes	582624	4115671
S897	Stanchion pair northeast of GZ	Yes	582784	4115912
S898	Stanchion pair northeast of GZ	Yes	582859	4116028
S899	Concrete pads and cable anchors	Yes	582864	4116036
S900	Instrument station	Yes	582841	4116163
S901	Electrical panel and backboard	No	583000	4115952
S902	Concrete pad	Yes	583082	4115890
S903	Battery vault	Yes	583081	4115848
S904	Stanchion pair southeast of GZ	Yes	582924	4115731
S905	Electrical switch boxes and backboard	No	582786	4115741
S906	French personnel shelter II-4	Yes	582701	4115546
S907	French personnel shelter II-3	Yes	582723	4115544
S908	French personnel shelter II-1	Yes	582752	4115543

Continued

Table 6. Building and Structures Recorded within 26NY14794 (continued).

SHPO Resource #	Description	Contributing to D104	UTM (Zone 11 NAD27)	
			Easting	Northing
S909	French personnel shelter II-5	Yes	582780	4115531
S910	French personnel shelter II-2	Yes	582798	4115548
S911	German personnel shelter RAa	Yes	582831	4115608
S912	German personnel shelter RAb	Yes	582835	4115591
S913	German personnel shelter CAa	Yes	582861	4115601
S914	German personnel shelter RAc	Yes	582842	4115559
S915	German personnel shelter CAb	Yes	582868	4115569
S916	German personnel shelter RAd	Yes	582854	4115508
S917	German personnel shelter RCa	Yes	582895	4115331
S918	German personnel shelter RCb	Yes	582940	4115135
S919	Station 8-30.7-8007 BRL Structure	Yes	582960	4115141
S920	Three gauge instrument stands	Yes	582929	4115082
S921	Station 8-22-6003 fluor on concrete pad	Yes	582518	4115508
S923	Emergency exit shaft and vent stack for S918	Yes	582940	4115135

Smoky Tower Components

During the Smoky test, the 700-ft tall tower was partially vaporized and destroyed; however, a series of 12 components of the tower are extant structures in the Smoky test area. These are the tower foundation (S887), the elevator pit (S888), the hoist foundation (S889), seven anchor blocks with inset stanchion pairs used for guy wire support (S893, S894, S895, S896, S897, S898, S904), and anchors for an instrumentation cable pulley system (S890, 899). As described in the Historic Context section (pages 24-39), these resources were physically connected to the tower structure and were, therefore, integral components of the Smoky tower.

Tower Foundation

S887 is the T-2c tower foundation used to support the four Smoky tower legs at UTM coordinate 582743 E, 4115849 N (Zone 11 NAD27) (Figure 75). S887 matches the location of the T-2c tower foundation as recorded in the Instrument Chart for Operation Plumbbob (DOE 1957). Most of the foundation is below the ground surface, including the concrete pads and concrete pedestals. The only visible portion of the structure is two metal tower leg base plates to the southeast and southwest of ground zero measuring 0.6 x 0.6 m (2 x 2 ft). Bolts protrude through the corners of the base plates and marks indicate where the round tower legs were welded to the plates. A metal plate under the southwest base plate is also partially visible and measures 0.9 m x 0.9 m (3 ft x 3 ft). The metal plate under the southeast base plate is not visible. The area around the base plates contains metal legs, tensioning rods, and fragments from the tower. The remains of the concrete elevator pit and concrete pad (S888) are south of the tower foundation (S887).

Concrete Elevator Pit

S888 is the concrete elevator pit and concrete pad at UTM coordinate 582746 E, 4115848 N (Zone 11 NAD27) (Figure 76). The location of S888 concurs with the Smoky site plan and is along the south edge of the tower foundation (S887). The elevator pit generally conforms to the measurements from the engineering drawings (see page 39, Figures 24-28), but its condition hindered confirmation of measurements in the field. In addition, metal tower fragments fill the pit so the condition of the concrete blocks at the bottom of the elevator pit could not be assessed. No evidence of the post and chain system around the top edge of the pit is visible. Rebar is exposed along the walls of the elevator pit. A concrete pad adjacent to the south edge of the pit conforms to the length measurement of a concrete foundation in engineering drawings. The concrete is deteriorated in some areas and the pad is partially covered by alluvium and tower parts.

Concrete Elevator Hoist Pad

S889 is the concrete elevator hoist pad for the Smoky tower elevator at UTM coordinate 582730 E, 4115858 N (Zone 11 NAD27) (Figure 77). The location concurs with the Smoky site plan and field measurements generally conform to engineering drawings (Figure 78). A measurement of thickness was not obtained because the concrete pad extends below the ground surface. The concrete pad is cracked and deteriorated. Bolts for the attachment of the hoist are still visible on the edge of the concrete pad and match the design and placement of bolts on engineering drawings. The cable drum and a triangular pedestal base are on the southeast facing slope of Station 8-22-6001, a cokehill (S891), directly northwest of the concrete elevator hoist pad. Box beams, guy cable, metal plates, and a hoist motor armature are on or near the pad surface.

Figure 75. S887, southeast and southwest metal base plates (at arrows) for the Smoky tower legs, view southwest (2012).

Figure 76. S888, elevator pit (at arrow) for the Smoky tower elevator, view southeast (2012).

Figure 77. S889, elevator hoist pad for the Smoky tower elevator, view northeast (2012).

Tower Stanchion Pairs: S893, S894, S895, S896, S897, S898, S904:

As discussed in the Historic Context section (page 31), the Smoky tower was supported by pairs of permanent guy cables oriented in four directions (Figures 17, 18, and 22). Each cable pair was attached at ground level to permanent stanchions, consisting of an anchor assembly and tensioning mechanism embedded in a concrete anchor block. Of the 12 stanchion pairs, seven were recorded (Figure 78).

S893 is a tower stanchion pair approximately 76 m (250 ft) northwest of ground zero at UTM coordinate 582677 E, 4115887 N (Zone 11 NAD27) (Figure 79). S893 was recorded during field survey and conforms to the location of a stanchion pair approximately 76 m (250 ft) northwest of ground zero on the plot plan (Figure 78). Both stanchions retain the I-beam and tensioning mechanis, but the I-beams have been slightly deformed from the blast; however, the tensioning mechanisms still point in the direction of ground zero. A 5.39 cm (2 1/8 inches) diameter guy cable, approximately 7 m (23 ft) in length, is attached to the closed bridge strand socket of each stanchion with the other ends buried in alluvium. The surface of the anchor block is covered with gravel and is not visible.

S894 is a tower stanchion pair approximately 152 m (500 ft) northwest of ground zero for the Smoky atmospheric nuclear test (Figure 80). It is at UTM coordinate 582613 E, 4115931 N (Zone 11 NAD27). S894 was recorded during field survey and conforms to the location of a stanchion pair approximately 152 m (500 ft) northwest of ground zero on the plot plan (Figure 78). Both stanchions retain the I-beam and tensioning mechanism. The I-beams have been slightly deformed from the blast. One of the tensioning mechanisms points toward the direction of ground zero, the other in the opposite direction. This was probably due to the blast and whip effect of the cable that turned the tensioning mechanism on the hub. A 5.39 cm (2 1/8 inches) diameter guy cable is still attached to the closed bridge strand socket of each stanchion. The surface of the anchor block is covered with gravel and is not visible.

S895 is a tower stanchion pair approximately 76 m (250 ft) southwest of ground zero (Figure 81). It is at UTM coordinate 582702 E, 4115784 N (Zone 11 NAD27). S895 was recorded during field survey and conforms to the location of a stanchion pair approximately 76 m (250 ft) southwest of ground zero on the plot plan (Figure 78). Both stanchions retain the I-beam and tensioning mechanism. The I-beams have been slightly deformed from the blast; however, the tensioning mechanisms still point in the direction of ground zero. In the center of the closed bridge strand sockets, a 5.39 cm (2 1/8 inches) diameter guy cable attached to each stanchion. Trinitite was formed during the nuclear detonation and contains byproducts of nuclear material melted together with sand during the fireball phase. Trinitite is fused to a portion of the I-beam, U-bolt, and bridge strand socket of the easternmost stanchion. Yellow spray paint, applied post-test, is visible on this stanchion. The number "40" is painted on the I-beam and yellow paint is visible on the trinitite. The surface of the anchor block is covered with gravel and is not visible.

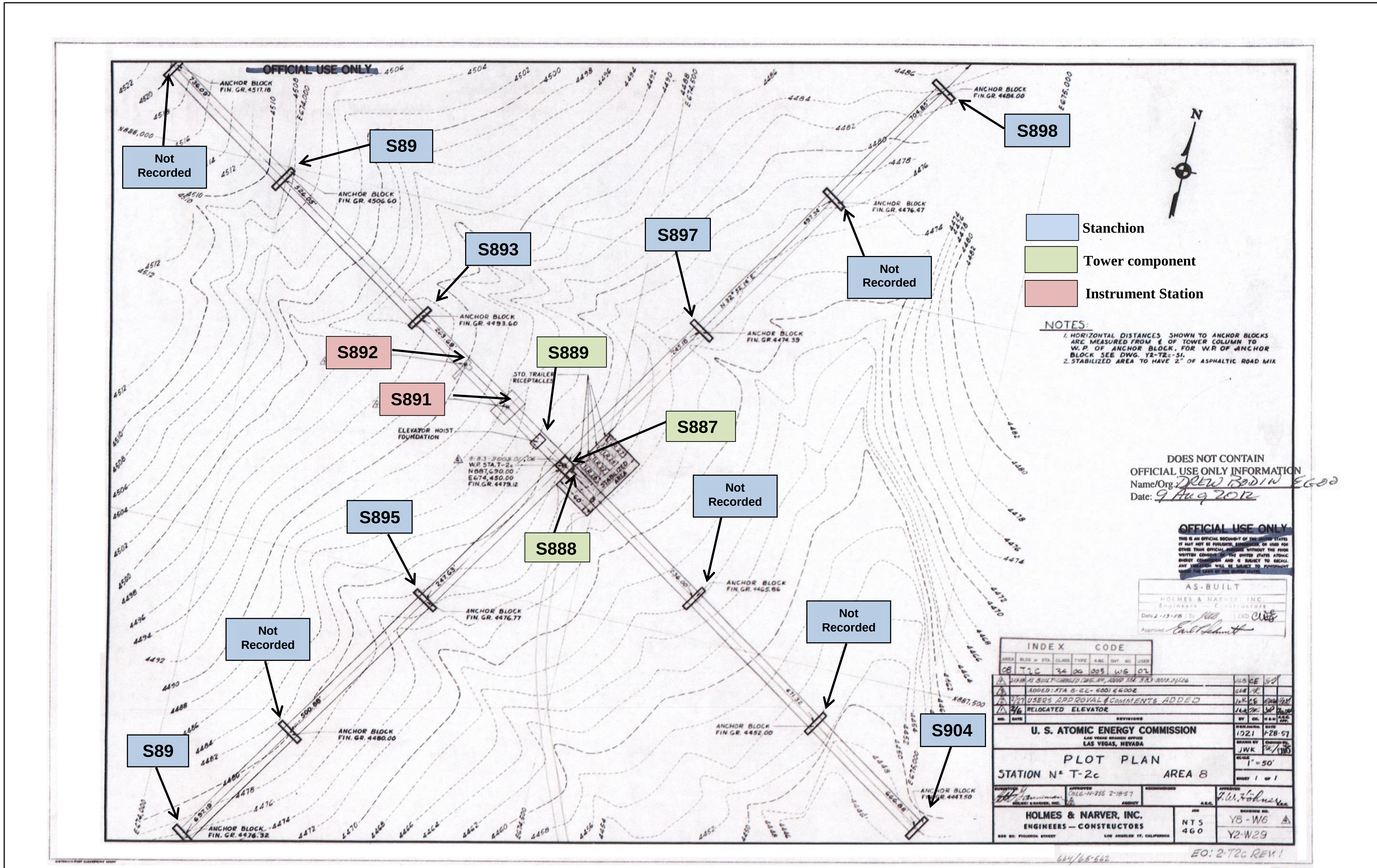


Figure 78. Smoky 700 ft tower plot plan showing stanchions, tower components, and instrument station locations (modified from Holmes & Narver, Inc. drawing Y8-W6 on file at the NNSA/NFO, National Nuclear Testing Archive, Las Vegas, Nevada).

S896 is the tower stanchion pair approximately 213 m (700 ft) southwest of ground zero for the Smoky atmospheric nuclear test (Figure 82). It is at UTM coordinate 582624 E, 4115671 N (Zone 11 NAD27). S896 was recorded during field survey and conforms to the location of a stanchion pair approximately 213 m (700 ft) southwest of ground zero on the plot plan (Figure 78). Both stanchions retain the I-beam and tensioning mechanism. The I-beams have been slightly deformed from the blast and both tensioning mechanisms face away from ground zero. This was probably due to the blast and whip effect of the cable that turned the tensioning mechanisms on their hubs. A 5.39 cm (2 1/8 inches) diameter guy cable is attached to the strand socket of each stanchion. Trinitite is fused to a portion of the U-bolt and closed bridge strand socket on the easternmost stanchion. Yellow spray paint has been applied post-test. The letters "ACL" has been painted on the westernmost stanchion's I-beam. Other spray paint markings are visible but not legible on both of the stanchions. The surface of the anchor block is covered with gravel and is not visible.

S897 is the tower stanchion pair approximately 76 m (249 ft) northeast of ground zero (Figure 83). It is at UTM coordinate 582784 E, 4115912 N (Zone 11 NAD27). S897 was recorded during field survey and conforms to the location of a stanchion pair approximately 76 m (249 ft) northeast of ground zero on the plot plan (Figure 78). One stanchion consists of two pieces of I-beam embedded in concrete at a 45 degree angle. The second stanchion consists of two rectangular pieces of I-beam with a square metal end cap assembly also embedded in concrete at a 45 degree angle. The I-beams have both been cut and the adjustable tensioning mechanisms are missing. The anchor block is covered with gravel and is not visible.

S898 is the tower stanchion pair approximately 213 m (700 ft) northeast of ground zero for the Smoky atmospheric nuclear test (Figure 84). It is at UTM coordinate 582859 E, 4116028 N (Zone 11 NAD27). S898 was recorded during field survey and conforms to the location of a stanchion pair approximately 213 m (700 ft) northeast of ground zero on the plot plan (Figure 78). The westernmost stanchion's I-beam is embedded in a concrete anchor block at a 45 degree angle. The other stanchion has been significantly deformed and twisted. The I-beams have both been cut and the adjustable tensioning mechanisms are missing. The anchor block is covered with gravel and is not visible.

S904 is a tower stanchion pair approximately 213 m (700 ft) southeast of ground zero (Figure 85). It is at UTM coordinate 582924 E, 4115731 N (Zone 11 NAD27). S904 was recorded during field survey and conforms to the location of a stanchion pair approximately 213 m (700 ft) southeast of ground zero on the plot plan (Figure 78). Both stanchions are significantly twisted and deformed. The I-beams have both been cut and the adjustable tensioning mechanisms are missing. Most of the concrete anchor block is covered with alluvium and only a small area of the concrete surface is visible along the southwestern edge of the block.


Figure 79. S893, tower stanchion pair, view southeast (2012).


Figure 80. S894, tower stanchion pair, view north (2012).


Figure 81. S895, tower stanchion pair, view southeast (2012).

Figure 82. S896, tower stanchion pair, view northeast (2012).

Figure 83. S897, tower stanchion pair, view northeast (2012).

Figure 84. S898, tower stanchion pair, view southwest (2012).

Figure 85. S904, tower stanchion pair, view northwest (2012).

Instrumentation Cable System

Five independent cable systems were secured to the tower for the attachment of experiments used in Project 8.3b (Instrumentation for Measuring Effects Phenomena inside the Fireball) (see pages 31 and 77). According to the engineering drawings (Figures 23, 86-87), cable systems 1, 2, 4, and 5 were 701 m (2,300 ft) in length and cable system 3 was 1,158 m (3,800 ft) in length. All cables attached to the 213.4 m (700 ft) level of the tower. From here, the cables were directed over pulleys the top of the shot tower and down the outside of the tower through additional pulleys secured at the surface 15.24 m (50 ft) from the northeast side of the Smoky tower to a reinforced concrete anchor block. The anchor block was 7.8 m (25 ft 6 inches) long by 2.43 meters (8 ft) wide and 0.76 m (2 ft 6 inches) thick. The surface of the anchor block was set level with the surface grade with the exception of a 60 cm (2 ft) wide section running the length of the center of the block. This central section rose 20.3 cm (8 inches) above the ground surface. The five pulleys were anchored into this raised central section of the anchor block. Twenty instruments or specimens attached to these cable systems were lowered or raised to the desired height using this pulley system. The pulley system anchor block (S890) and the anchor blocks for cable systems 2 and 4 (S899) were recorded in the field.

S890 is the reinforced concrete pulley anchor block with five steel attachments for cables at UTM coordinate 582747 E, 4115863 N (Zone 11 NAD27) (Figure 88). The concrete anchor block is 13.4 m (44 ft) northeast of the ground zero and the central section is visible above the ground surface, but the rest of the anchor block is covered. Field measurements of the raised portion and metal anchors match the dimensions provided in engineering drawings (Figure 86). The five steel pulley attachments are spaced across the top surface of the block. Each attachment consists of two pieces of 10 cm (4 inches) angle iron 20.3 cm (8 inches) in height and 5 cm (2 inches) apart. The top of the angle iron has been cut at a 45 degree angle. The attachments are centered on the block and are spaced at 0.3 m (1 ft), 2.2 m (7 ft 2 inches), 3.9 m (12 ft 10 inches), 5.8 m (19 ft), and 7.5 m (24 ft 7 inches) from the north end of the anchor block. Cable and wire are near the anchor block and cable from cable system #3 is still attached to the center attachment. The concrete is cracked and deteriorated.

S899 consists of the two concrete dead man anchors for cable systems 2 and 4 (Figure 89). The anchor pads are at UTM coordinate 582864 E, 4116036 N (Zone 11 NAD27). They are 243 m (800 ft) northeast of ground zero and 10.3 m (34 ft) northeast of tower stanchion pair S898. The south anchor was used to anchor cable system #2 and the north anchor was used for cable system #4. Field measurements of the concrete blocks and anchors of S899 match the dimensions provided in engineering drawings (Figure 87). They measure 1.8 m x 1.2 m (6 ft x 4 ft) and are 1.85 m (6 ft 1 inch) apart. Two metal plates protrude 25.4 cm (10 inches) out of the center of the southwest edge of the concrete anchor blocks. They are each 10 cm (4 inches) wide and are spaced 2.54 cm (1 inch) apart. A 2.54 cm (1 inch) pin secured the cable through a thimble still present between the plates. The cable and U-bolts are absent from both anchors.

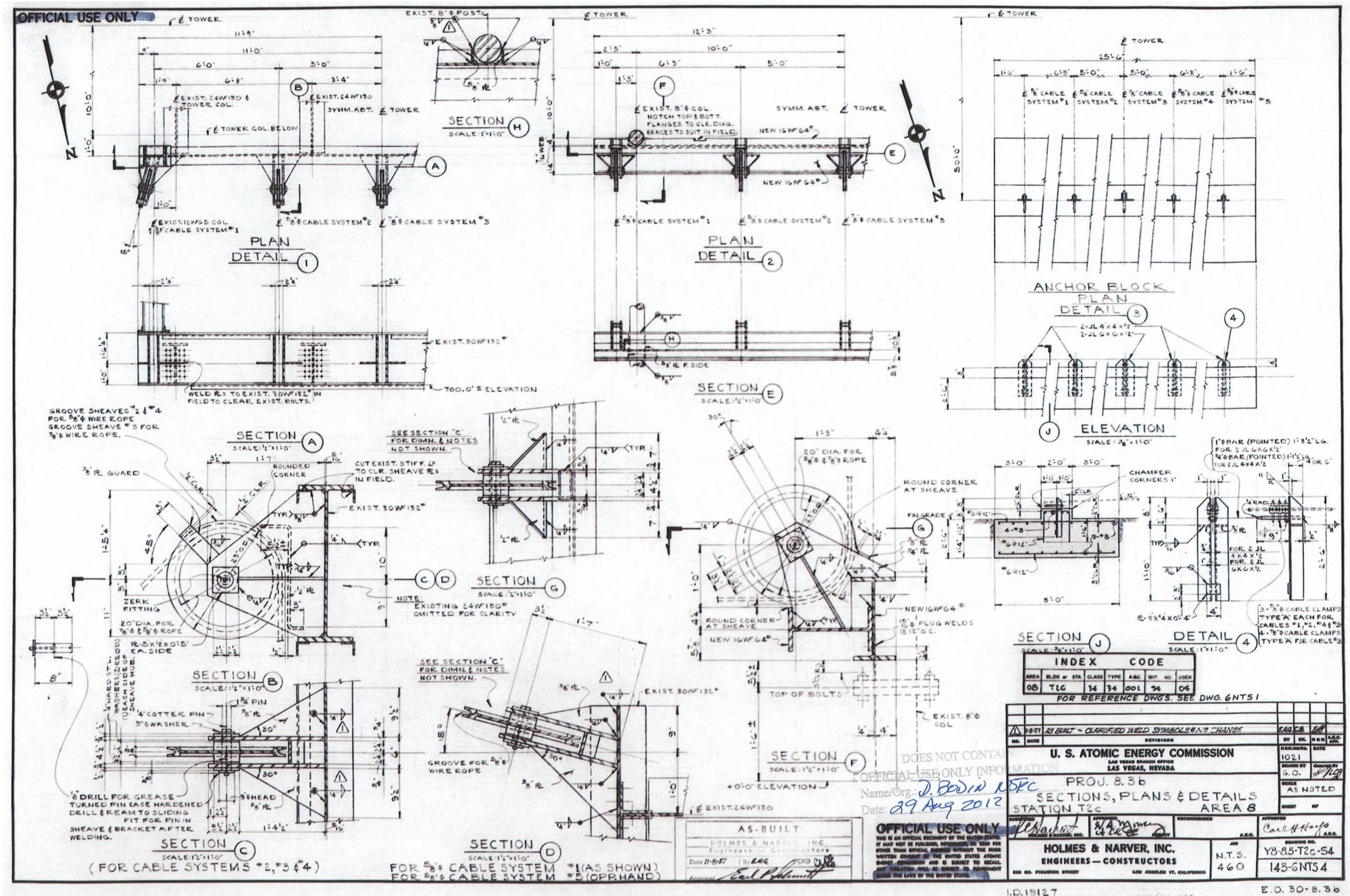
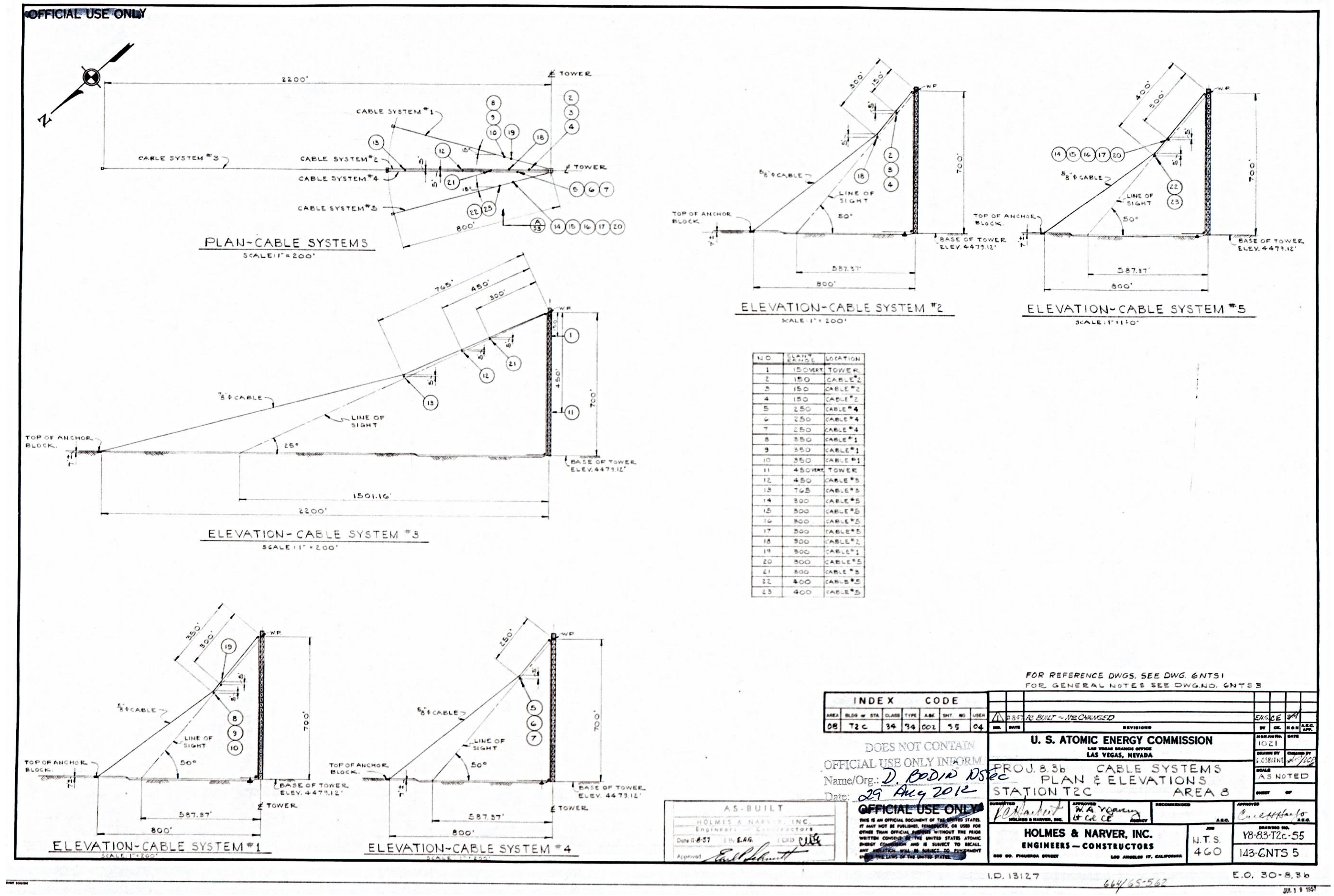


Figure 86. Pulley anchor block (S890) for instrumentation cable system, sections, plans, and details.



NO.	SLANT RANGE	LOCATION
1	150 VERT.	TOWER
2	150	CABLE #2
3	150	CABLE #2
4	150	CABLE #2
5	250	CABLE #4
6	250	CABLE #4
7	250	CABLE #4
8	350	CABLE #1
9	350	CABLE #1
10	350	CABLE #1
11	450 VERT.	TOWER
12	450	CABLE #3
13	765	CABLE #3
14	500	CABLE #5
15	500	CABLE #5
16	500	CABLE #5
17	500	CABLE #5
18	300	CABLE #2
19	300	CABLE #1
20	500	CABLE #5
21	300	CABLE #3
22	400	CABLE #5
23	400	CABLE #5

Figure 87. Layout of experiments for instrumentation cable system, plan and elevations.

Figure 88. S890, anchor block for pulley cable system, view east (2012).

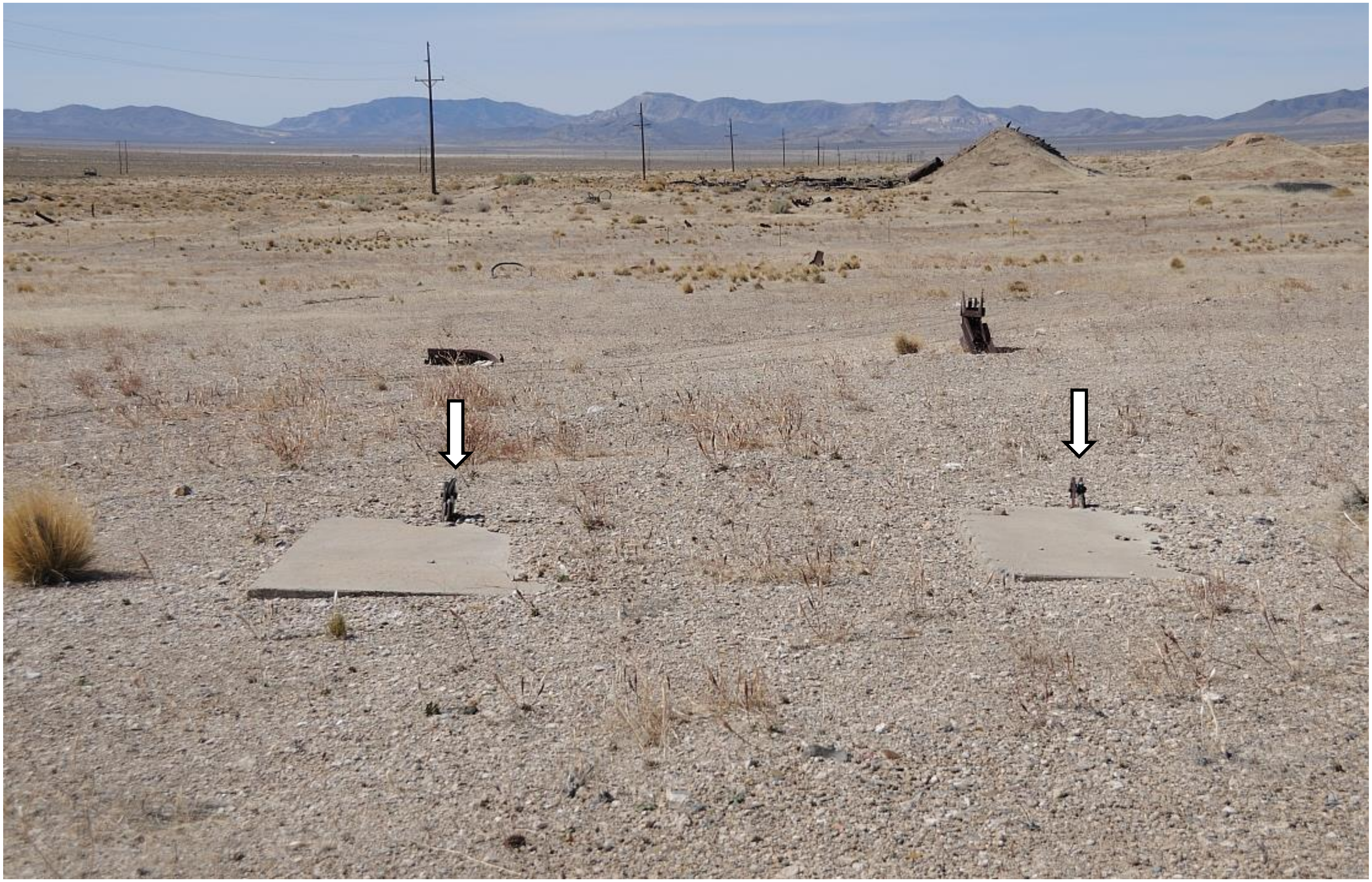


Figure 89. S899, concrete anchor pads and stanchions for instrumentation cable systems 2 and 4 (at arrows), view southwest (2012).

The anchor for cable system #5 was also located and photographed in the field but it was not recorded in detail. Anchor #5 is approximately at UTM coordinate 582819 E 4116073N (Zone 11 NAD27). Unlike the anchors for cable systems 2 and 4, a small portion of cable and three U-bolts remain attached to the anchor.

Instrument Stations

Cokehill, Fluor and Converter, and Fluor Stand (S891, S892, S921)

Three stations in the Smoky test area are associated with a scientific experiment conducted under Program 22, a program studying reaction history of electronics, nuclear radiation measurements, remote technique developments, and telemetry (Johnson 1957; Harris et al. 1981a). These are a cokehill (Station 8-22-6001, S891), a fluor and converter for the cokehill (8-22-6002, S892), and a fluor on a concrete pad (8-22-6003, S921). These stations were used for a fluor array diagnostic experiment (page 83). For the Smoky test, charcoal (not coal/coke) was used as the fluor material.

A critical component of the fluor stations was a system of mirrors used to transmit signals (images) to either the optical section of the 2-300 instrument blockhouse in Area 2 or the 2-380 Fast Photo Bunker in Area 2. Typically, in the engineering design for an atmospheric tower test, coaxial cable ran underground between the ground zero area and a nearby concrete bunker. The cable carried a signal from ground zero instruments to recording instrumentation housed in bunkers. Smoky is located in Area 8 of the NNSS, but the diagnostics for the test were conducted at the Area 2 bunker complex, 6.4 km (4 miles) southwest of ground zero. Because of the distance involved, standard electronics were not possible and photographic and optical channel techniques were used to measure test effects (Johnson 1957). For the fluor experiments, mirrors were used to relay signals or images. The cokehill is in a direct line-of-sight with a station described as a turning mirror for 8-22-6001, 4.2 km (2.6 miles) southwest of the cokehill. The turning mirror is in a direct line-of-sight with the optical section of the 2-300 Area 2 instrument blockhouse and the 2-380 Area 2 Fast Photo Bunker. The 2-300 station is the main instrument bunker in the Area 2 bunker complex. It was recorded in 1995 as site 26NY9298 and determined eligible to the NRHP (Edwards and Johnson 1995).

S891 is Station 8-22-6001, a cokehill located near the ground zero area of the Smoky test at UTM coordinate 582772 E, 4115868 N (Zone 11 NAD27) (Figure 78). The cokehill consists of two components, the cokehill construction and an earthen berm (Figure 90). S891 (Station 8-22-6001) is listed in the Instrument Chart for Operation Plumbbob (DOE 1957) as a cokehill with the dimensions of 12.2 m (40 ft) long by 7.6 m (25 ft) wide and 91 cm (3 ft) high. According to the Smoky plot plan (Figure 22), the cokehill is rectangular with the long axis perpendicular to the Smoky tower. No engineering drawings or detailed descriptions of the station have been found, but in a historic document (Holmes & Narver, Inc. 1958), it is described as five tiered bays constructed with milled lumber set against a compacted soil mound.

The current location of Station 8-22-6001 (S891) matches the location in the Instrument Chart (DOE 1957). The structure is 17.2 m (100 ft) northwest of ground zero and appears as a prominent man-made hill of gravelly alluvium. The compacted sediment mound functioned as an

earthen berm on the southeast, northeast, and southwest sides of the cokehill component, visible as a plywood and charcoal briquette construction on the northwest side of the hill facing away from ground zero. The earthen berm is a substantive feature on the landscape. It measures 50 m (164 ft) northeast-southwest by 25 m (82 ft) northwest-southeast and is approximately 6 m (19 ft 8 inches) in height. On the southeast slope, facing ground zero, metal objects from the T-2c tower are visible. These include the cable drum and a triangular pedestal base (associated with the S889 concrete elevator hoist pad), guy wire cable, and miscellaneous metal fragments. On the opposite side of the hill, facing away from ground zero, wood beams, lumber, and regularly formed charcoal briquettes cover approximately a third of the northwest facing surface. The charcoal briquettes are in an area roughly conforming to the cokehill dimensions of 12.2 m (40 ft) long by 7.6 m (25 ft) wide provided in the Instrument Chart (DOE 1957). The briquettes are densely packed and the boundary between the gravelly alluvium and charcoal is abrupt, suggesting the charcoal concentration has significant depth. A line of at least 12 evenly spaced upright wood beams line the charcoal briquette concentration, beginning just below the crest of the hill. Most of these are charred and broken slightly above the hill surface. Charred and fragmented beams are within the charcoal concentration along with charred milled lumber boards. The beams and boards are the remains of the five tiered bays that functioned as cribbing to hold charcoal for the cokehill component of the structure.

S892 is Station 8-22-6002, a fluor and converter (DOE 1957) (Figure 91). It is near the ground zero area at UTM coordinate 582695 E, 4115879 N (Zone 11 NAD27) (Figure 78). No engineering drawings of Station 8-22-6002 have been found, but the station is described in a historic document as an underground reinforced concrete structure with “west” and “east” sections (Holmes & Narver, Inc. 1958). According to the description, the west section measured 1.8 m x 3.2 m (6 ft x 10 ft 6 inches) and the east section measured 1.37 m x 2.4 m (4 ft 4 inches x 8 ft). Both sections had 1.7 m (5 ft 8 inches) high interiors. The concrete structure was covered with roofing paper and ½-inch plywood over a lumber roof made with 4-x-12s which was in turn covered with 1.3 m (4 ft 6 inches) of compacted fill. The structure had a concrete opening extending from the east section. A 1.3 m (4 ft 6 inches) diameter 6.1 m (20 ft) long metal pipe extended from the west section.

The current location of Station 8-22-6002 (S892) matches the location in the Instrument Chart (DOE 1957). S892 appears as an oblong, man-made hill covering an open metal pipe and concrete walls. The hill is of gravelly alluvium and is 6.5 m (21 ft) northwest of the cokehill (S891). The hill has the same overall configuration and orientation as the cokehill, although smaller. It measures 38 m (125 ft) northeast-southwest by 20 m (66 ft) northwest-southeast and is approximately 5 m (16 ft 5 inches) in height. The man-made hill is the compacted fill covering the instrument station. The metal pipe is 1.37 m (4 ft 6 inches) in diameter and extends horizontally southwest-northeast, aligned with the long axis of the hill. The southwestern end of the pipe is open and the interior of the pipe is exposed. The pipe possibly functioned as a horizontal periscope, relaying signals to a mirror house. On the opposite end of the hill, two 1 m x 2.5 m (3 ft 3 inch x 8 ft 2 inches) rebar-reinforced concrete walls are visible. The walls are spaced 3 m (9 ft 10 inches) apart and sand bags (now disintegrated) with finer grained sediment (no gravels) fill the area between the walls. The underground concrete rooms and the roof are not visible.

S921 is a concrete pad used as the foundation for a fluor stand (Figures 92 and 93). The pad and stand are Station 8-22-6003 at UTM coordinate 582518 E, 4115508 N (Zone 11 NAD27). S921 is 411 m (1,350 ft) southwest of ground zero. An engineering drawing illustrates the plan and details of the fluor mounting stand and concrete foundation. The mounting stand was 3.05 m (10 ft) long by 2.4 m (8 ft) wide by 3.05 m (10 ft) high wood structure anchored to a concrete pad. The structure had a wood platform 3.05 m (10 ft) above the pad with a wood ladder for access and wood rails lining the platform. With the exception of the four corners, the concrete pad was 4 inches thick and set on a level surface grade. The corners of the pad were 30.48 cm (1 ft) thick and set 20.32 cm (8 inches) below the surface. The corners of the concrete pad were thicker to accommodate three 8-inch long attachment bolts.

All that remains of Station 8-22-6003 is the concrete pad that supported the mounting stand. The concrete pad was given the designation S921. The location of the pad matches the location in the Instrument Chart (DOE 1957). The surface of the pad is cracked, the corners are broken, and the attachment bolts for the fluor mounting stand are no longer present. No physical evidence of the wood structure or fluor material (i.e., charcoal) was observed in the general area.

Underground Instrument Station

S900 is a buried instrument station at UTM coordinate 582841 E, 4116163 N (Zone 11 NAD27). S900 is 330 m (1,082 ft) northeast of ground zero (Figure 94). The condition and design of the subsurface portion of the structure is not known. The only visible feature of the structure is a hook-shaped vent pipe that extends from a concrete pad. The vent pipe is 10 cm (4 inches) in diameter and 33 cm (1 ft 1 inch) vertical above a concrete surface. The concrete surface is only visible south and west of the vent pipe. Most of the concrete surface is covered with gravel and the dimensions are not known. The surface around the station has been bladed.

Battery Vault

S903 is an underground concrete battery vault at UTM coordinate 583081 E, 4115848 N (Zone 11 NAD27) (Figure 95). No engineering drawings were found for this specific structure. An engineering drawing (Holmes & Narver, Inc. 1957) details a similar structure that acted as a battery shelter. That structure was not located in the field. Measurements for S903 do not correspond to the engineering drawing, but it is possible that S903 has similar construction specifications.

S903 is 40 m (131 ft 2 inches) south of S902, a concrete pad. The vault is 1.82 m (6 ft) in length by 1.52 m (5 ft) in width by 1.2 m (4 ft) deep. It has one 152 cm (4 ft 11 inches) by 91.4 cm (3 ft) wide by 10 cm (4 inches) thick fixed cover and an adjacent removable concrete cover panel. The removable panel has the same dimensions as the fixed panel but is edged with 10 cm (4 inches) angle iron and has a metal eye bolt for attachment of a cable for removal. Inside the vault, embedded in the west wall, are metal rungs access. A metal rack containing dry cell batteries is along the east wall. Metal debris rests on top of the metal rack. The floor of the vault is covered by gravel and brush and is not visible.


Figure 90. S891, cokehill and earthen berm, view southeast (2012).

Figure 91. S892, fluor and converter for cokehill, view northwest (2012).

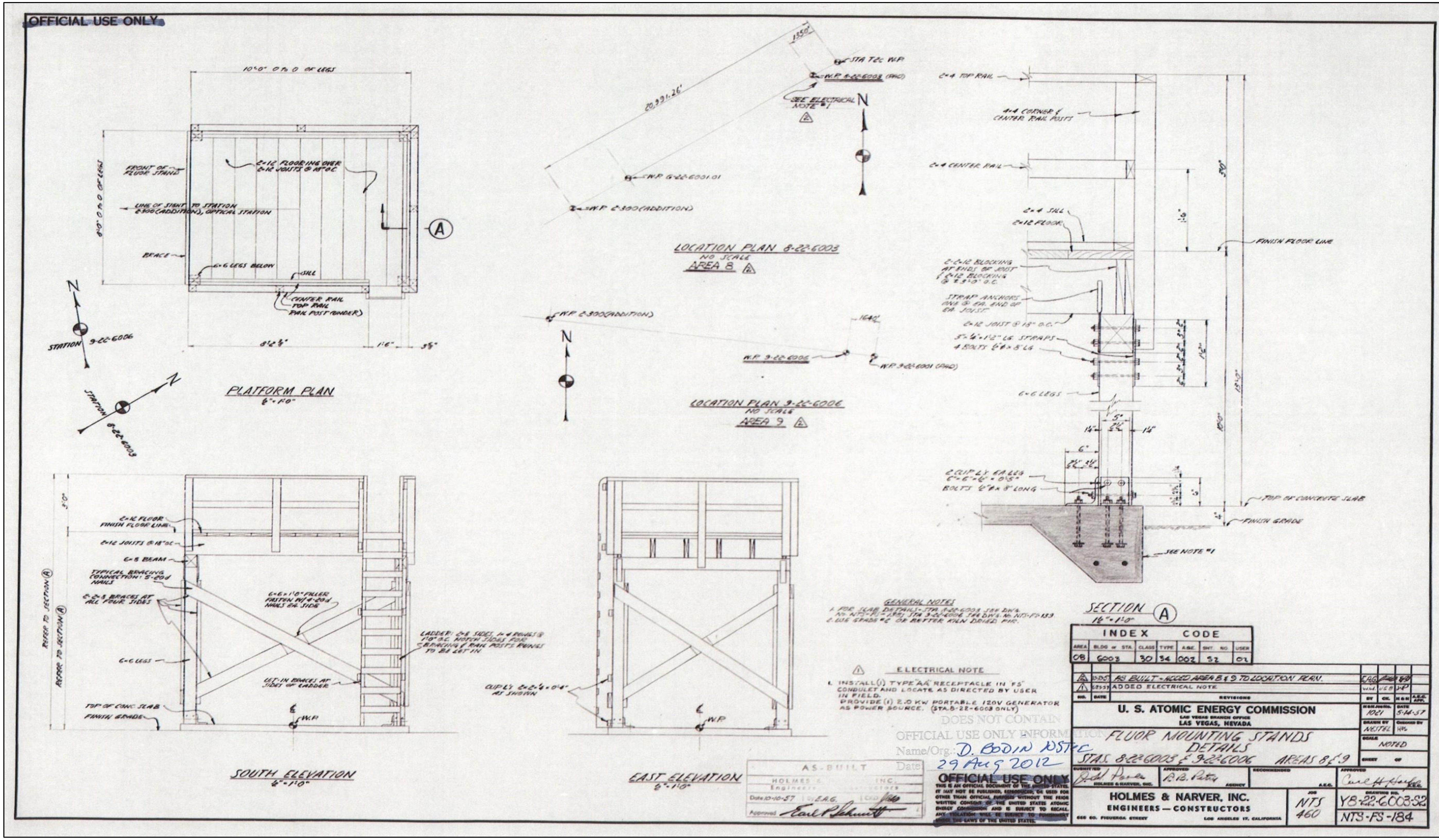


Figure 92. S921, fluor on a concrete pad, fluor mounting stand details.

Figure 93. S921, concrete pad foundation of fluor mounting stand, view south (2012).

Figure 94. S900, hook-shaped vent pipe and concrete slab of buried instrument station, view south-southwest (2012).

Figure 95. S903, battery vault, view west (2012).

Ballistic Research Laboratory (BRL) Structure

S919 is the BRL underground instrument shelter, Station 8-30.7-8007 (DOE 1957). It is at UTM coordinate 582960 E, 4115141 N (Zone 11 NAD27). The BRL is 35 m (115 ft) east of German shelter RCb (S918) and 740.6 m (2,430 ft) south of ground zero for the Smoky atmospheric nuclear test. S919 was used by the U.S. Army Ballistic Research Laboratory for Project 1.8 (Effects of Rough and Sloping Terrain on Airblast Phenomena) and Projects 30.5, 30.6, and 30.7, which tested the underground personnel shelters and their instrumentation (Harris et al. 1981a:111; Harris et al. 1981b:46) (see page 75). S919 housed electronic and self-recording instrumentation for these projects.

According to the engineering drawing (Figure 96), the entire BRL instrument shelter was 3.1 m (10 ft 4 inches) wide by 4.4 m (14 ft 4 inches) in length by 3.2 m (10 ft 5 inches) in height. The interior chamber of the underground shelter is 2.4 m (8 ft) wide by 3.7 m (12 ft) long by 2.4 m (8 ft) deep. The reinforced concrete walls were 35.5 cm (1 ft 2 inches) thick and the structure was sealed with a reinforced concrete roof slab measuring 3.1 m (10 ft 4 inches) wide and 4.4 m (14 ft 4 inches) long. The interior of the shelter was accessed through a hatch located in the southwest corner of the roof slab. The entry hatch opening was 91 cm by 91 cm (3 ft by 3 ft). From the hatch, eight ladder rungs attached to the south interior wall descended into the shelter. The rungs measured 41 cm (1 ft 4 inches) wide and 1.9 cm (3/4 inch) in diameter. The entry hatch was covered by a metal hatch cover measuring 102 cm by 102 cm (3 ft 4 1/2 inches by 3 ft 4 1/2 inches). Three 2 cm (8 inch) diameter schedule 40 steel ventilation pipes measuring 46 cm (1 ft 6 inches) long were installed through the roof slab with 10 cm (4 inches) protruding above the slab surface. On the ground surface, the pipes were capped with 30 cm (1 ft) standard 150# metal blind flanges. The opposite ends of the pipes were set flush with the ceiling of the underground shelter. One ventilation pipe was placed against each of the north, west, and east interior walls of the shelter. A 7.5 kw, single phase 110 volt portable generator was installed inside the underground shelter, but no documents discussing the specific instrumentation housed in the shelter have been found.

The location of the BRL instrument shelter (S919) was confirmed in the field (Figure 97). The concrete roof slab of S919 is near the present surface grade, but is mostly covered with gravelly alluvium and not visible. A 1.21 m by 1.21 m (4 ft by 4 ft) rectangular section of the roof slab containing the entry hatch is visible at the surface along with the three metal blind flanges capping the ventilation pipes. The metal hatch cover is partially buried to the north of the hatch opening. A frame made of plywood and 2-x-4 wood attached to the concrete with metal clips. This frame was not included in the original design of the shelter and was added sometime after the Smoky test.

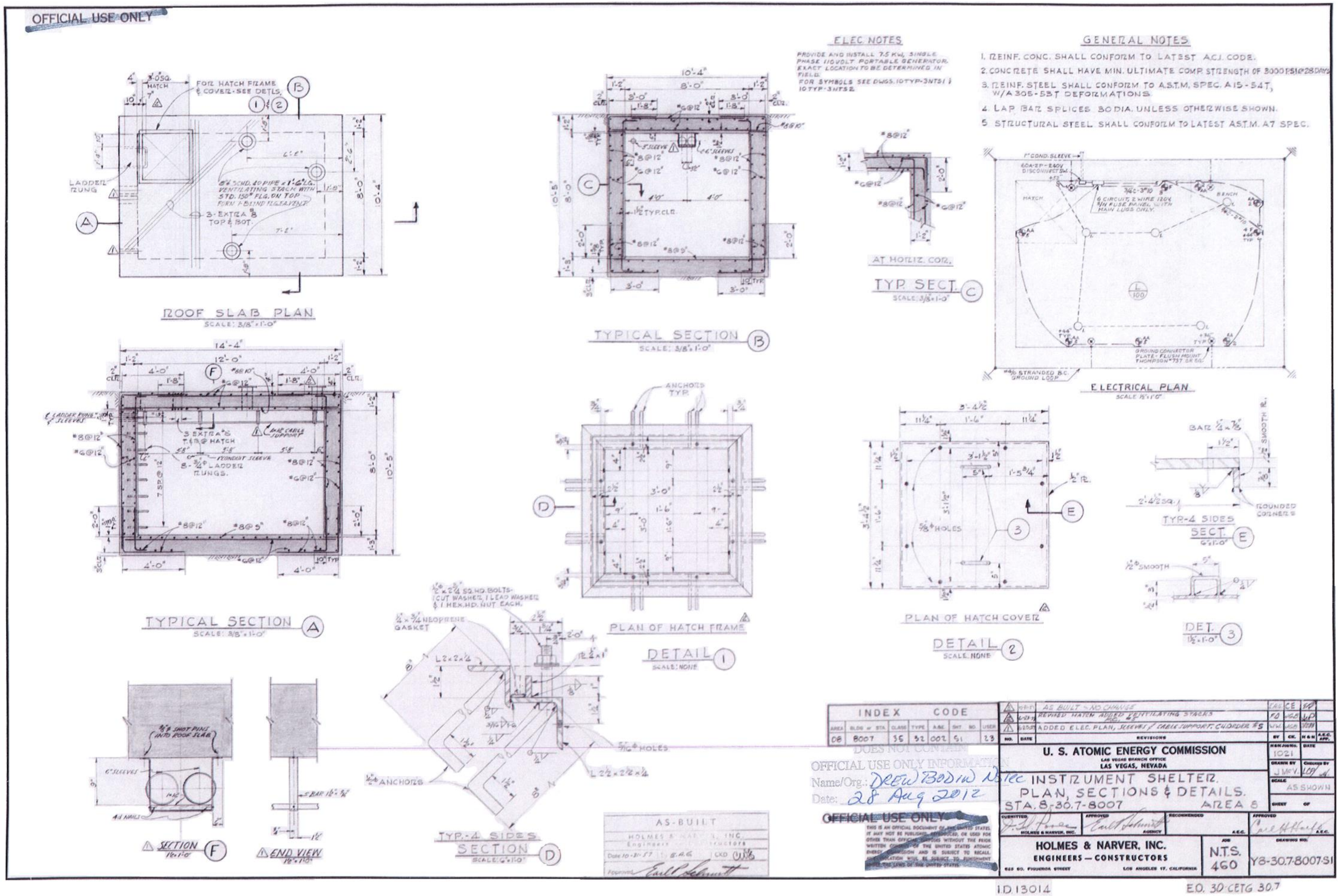


Figure 96. S919, Ballistic Research Laboratory instrument shelter, plan, sections, and details.


Figure 97. S919, Ballistic Research Laboratory underground instrument shelter, view west (2012).

Gauge Instrument Station

For the Smoky test, gauges were used for a program titled "Effects of Rough and Sloping Terrain on Airblast Phenomena" under Project 1.8a and Project 1.8c (Bryant et al. 1957) (see page 75). The objective of Project 1.8a was to determine the effects of rough terrain and steep slopes on blast-wave parameters and was sponsored by Ballistic Research Laboratory (BRL). The objective of Project 1.8c was to provide additional blast-wave measurements, specifically measurements of airblast phenomena along transects crossing different terrain features. The instrument transect ascended the steep terrain of the Smoky Hills north of the Smoky ground zero. Project 1.8c was sponsored jointly by BRL and Stanford Research Institute (SRI). For the two projects, gauge stations were aligned primarily along five blast lines: one to the south of ground zero (Line 1) and four to the north (Lines 2 through 5). All lines were part of Project 1.8a; only Lines 1 and 3 were used in Project 1.8c. Line 1 acted as a control for the experiments with the gauge stands placed on relatively level terrain at similar distances from ground zero as gauge stands along Lines 2 through 5 on ascending terrain. Wiancko and Ultradyne made the gauges and equipment used at the stations and William J. Miller Corporation provided the oscillograph recorders. The gauges were removed for data collection after the Smoky test. The majority of gauge stands used for Project 1.8c were from the Priscilla test on Frenchman Flat, June 24, 1957 (Bryant et al. 1957).

S920 consists of three gauge stands in close proximity to one another in a triangular pattern (Figure 98). The gauge stands are on Line 1 at 792 m (2,589 ft) south of ground zero and at UTM coordinate 582929 E, 4115082 N (Zone 11 NAD27). According to the Operation Plumbbob Instrument Chart (DOE 1957) and Bryant et al. (1957, Figures 2.5 and 6.1), two of the gauge stands are instrument stations, Station 8-1.8-9003.01 and Station 8-1.8-9004.01. The third gauge stand has no known designation. Station 8-1.8-9003.01 consists of one 1 m (3 ft) tall gauge stand and is 6 m (19 ft 7 inches) west of the concrete pad for Station 8-1.8-9004.01. The stand is constructed of a 1.02 m (3 ft 4 inches) upright pipe measuring 25.4 cm (10 inches) in diameter. Attached to the east side of the pipe near the top is a 25.4 cm (10 inches) diameter flange for the attachment of a pressure gauge. The top of the pipe is sealed with a metal plate. The stand had three gauges: a self-recording pressure-time gauge, a self-recording dynamic pressure-time gauge, and a self-recording pitch-time gauge. The self-recording pressure-time gauge was set up at ground level oriented toward ground zero. The dynamic pressure-time gauge and self-recording pitch-time gauge were set up 0.9 m (3 ft) above the ground. All gauges consisted of a glass disk, called an oscillograph, a motor element, and various pressure-sensing components. The basic recording medium of the self-recording gauge was an aluminized glass disk on which readings were scratched in by an osmium-tipped stylus. The drive motor that turned the disk was a self-contained oscillating balance wheel that acted as a simple harmonic reference generator. Motors with rotational speeds of 3 and 10 rpm were used. The light was guided to the disk using lucite tubing. The pressure-sensing element was a chamber formed by welding together at their edges two diaphragms, each of which had a series of concentric corrugations. The sensing element, recording mechanism, and initiation system for the pressure-time gauges was enclosed in a heavy airtight canister, the tip of which acted as a baffle plate, used to prevent the spread of sound or light in a particular direction (Bryant et al. 1957).

The standard dynamic pressure-time gauge, referred as a Q-gauge, had two separate pressure-sensing elements to record the total head and side-on pressures. The two elements were mounted at right angles to one another in a hollowed-out portion of the nose section of the gauge. The stylus of each of the two elements was arranged so that each could make a trace on an aluminized glass disk. The two traces were made at different radii and events recorded by each stylus simultaneously appeared on the recording disk. The nose section of the gauge contained the recording mechanisms screwed into a hollow cylindrical section, which contained the motor power supply and initiation circuit. By means of pipe unions the gauge was attached to the standard BRL mount. For the high-pressure region (dynamic pressures above 100 psi), a flange was welded to the end of the gauge to permit mounting to the standard high-pressure mount. The self-recording pitch-time gauge was a vane-type gauge that, depending on the manner it was mounted, may have been used to measure either pitch or yaw. The sensing vane was attached to a shaft threaded on the opposite end. The threaded section of the shaft connected to a movable carriage mounted between guides on rails. The shaft and carriage were threaded10 threads per inch; therefore, when the vane made one complete revolution of 360 degrees, the carriage advanced 0.1 inch. A stylus arm also had an osmium-tipped needle attached. It was attached to the carriage so that when the vane rotated the stylus scratched readings into a glass disk (Bryant et al. 1957).

Station 8-1.8-9004.01 had one 3 m (10 ft) tall gauge stand on a 1.8 x 2.4 m (6 ft x 7 ft 10 inches) concrete pad with eye bolts near each corner. The gauge stand is constructed of two 3.15 m (10 ft 4 inches) upright pipes 25.4 cm (10 inches) in diameter and spaced 0.91 m (3 ft) apart. Metal plates cover the two sides between the upright pipes and the tops are sealed with metal plates. Two 20.3 cm (8 inches) metal flanges for attachment of pressure gauges are near the top of the north pipe that face north and 0.91 m (3 ft) above the surface on the north pipe that face west. The station had three gauges: one conventional baffle-mounted gauge at surface level and two subsonic pitot tube gauges used to measure dynamic pressure at three feet and ten feet above the ground. These subsonic pitot tube gauges were modified from a previous Sandia-Wiancko model used during Operation Teapot.

The third gauge stand, with no known station designation, is 6 m (19 ft 10 inches) southwest of the concrete pad for Station 8-1.8-9004.01. It is constructed of two 7.62 cm (3 inches) diameter metal pipes 0.91 m (3 ft) in height. Horizontal and diagonal bracing are along each side of the pipes linking them together.


Figure 98. S920, series of gauge instrument stands, view east (2012).

Underground Personnel Shelters

As described in the Historic Context section (pages 39-67), 14 underground personnel shelters were constructed and used for diagnostic and test effects (Projects 30.6 and 30.7) during the Smoky test. The projects were undertaken by the Service National de la Protection Civile of France and the West German Government through their liaison Ammann & Whitney, Consulting Engineers. Each of the five French shelters and eight of the nine German shelters were identified and recorded in the field.

French Personnel Shelters: S906, S907, S908, S909, S910

S906 is the French underground rectangular concrete personnel Shelter II-4 (Station 8-30.6-8005) (DOE 1957). It is at UTM coordinate 582701 E, 4115546 N (Zone 11 NAD27). Shelter II-4 was the western most of the five French underground personnel structures constructed for the Smoky test. Shelter II-4 was placed 308 m (1,010 ft) south of the Smoky ground zero, at a location with a predicted overpressure of 132 psi.

The current condition of Shelter II-4, designated S906, matches the location and general description provided in Cohen and Dobbs (1962). The only portions of the structure visible on the surface are the entryways and the concrete ventilation stack (Figures 99 and 100). The antechamber is underground and not accessible. The rectangular north and south entrances are 3.96 m (13 ft) long x 1.63 m (5 ft 3 inches) wide, are 4.6 m (15 ft 1 1/2 inch) apart, and the long axis is aligned north-south to ground zero. The entrance walls are 30.5 cm (1 ft) thick. Stairs extend down the entrances to the underground antechamber. The vent is a 81.3 cm (2 ft 8 inches) diameter pipe set within a 2.59 m (8 ft 6 inches) long x 1.98 m (6 ft 6 inches) wide concrete pad. A 1.1 x 1.1 m (40 x 40 inches) 2-x-4 wood frame surrounds the vent pipe and is attached to the concrete pad with metal clips. Historic photographs taken after the Smoky test show no frames on the vent; therefore, the frame was added to the structure after the test. The concrete is cracked and the corners are broken off of the vent pad. The ground between the two entrances appears to have been excavated sometime after the test. This was probably done to access the main chamber to investigate structural damage resulting from the test. The excavation was partially refilled.

S907 is the French underground rectangular concrete personnel Shelter II-3 (Station 8-30.6-8004) (DOE 1957). It is at UTM coordinate 582723 E, 4115544 N (Zone 11 NAD27) (Figures 101 and 102). Shelter II-3 was placed 308 m (1,010.5 ft) from the Smoky ground zero, at a location with a predicted overpressure of 132 psi. The shelter was 21 m (69 ft) east of Shelter II-4 (S906) and 25 m (82 ft) west of Shelter II-1 (S908).

The current condition of Shelter II-3, designated S907, matches the location, engineering design, and general description provided in Cohen and Dobbs (1962). The only portions of the structure visible on the surface are the entryways and one vent pipe. Both of the concrete vent stacks are absent and the antechamber is underground and not accessible. The rectangular north and south entrances are 3.91 m (12 ft 10 inches) long by 1.63 m (5 ft 3 inches) wide, are 4.6 m (15 ft 1 1/2 inch) apart, and the long axis is aligned north-south to ground zero. The entrance walls are 30.5 cm (1 ft) thick. Stairs extend down the entrances to the underground antechamber. The entrances are partially filled with tumbleweeds. The vent pipe from the air intake stack

which broke off below the surface during the test is located 3.8 m (12 ft 6 inches) east of the south entrance. The ground east of the south entrance appears to have been excavated sometime after the test. This was probably done to access the antechamber to investigate structural damage resulting from the test. The excavation was partially refilled. The concrete is cracked and broken.

S908 is the French underground rectangular concrete personnel Shelter II-1 (Station 8-30.6-8001) (DOE 1957). It is at UTM coordinate 582752 E, 4115543 N (Zone 11 NAD27) (Figures 103 and 104). Shelter II-1 was placed 308 m (1,010.5 ft) from the Smoky ground zero, at a location with a predicted overpressure of 132 psi. The shelter was 16 m (52 ft) east of Shelter II-3 (S907) and 38 m (125 ft) west of Shelter II-2 (S910).

The current condition of Shelter II-1, designated S908, matches the location, engineering drawing, and general description provided in Cohen and Dobbs (1962). The only portions of the structure visible on the surface are the entryways, the emergency-exit shaft, the two air intake stacks, a broken section of an exhaust stack and pipe, the base of an exhaust stack, and the concrete structure containing the sand pit air filters. Historic photographs taken after the Smoky test show that the main chamber was excavated after the test along its south side, partially exposing the main shelter body and the west air intake vent stack. The excavation was not refilled and a portion of the main shelter body is still visible. The rectangular north and south entrances are 4.37 m (14 ft 4 inches) long by 1.63 m (5 ft 4 inches) wide, are 7.63 m (25 ft) apart, and their long axes are aligned north-south. The entrance walls are 29.2 cm (11 1/2 inches) thick. Stairs extend down from the entrances to the underground structure and both stairways are partially filled with tumbleweeds. The 2.3 m (7 ft 6 inches) square blast resistant emergency-exit hatch is 16.95 m (55 ft 6 inches) west and 1.87 m (6 ft 2 inches) south of the southwest corner of the north entrance. A frame made of 2-x-4's is attached to the concrete around the emergency-exit hatch opening with metal clips.

The concrete structure containing the sand pit air filtration system is 1 m (3 ft 3 inches) north and west of the northwest corner of the south entrance. The sand pit structure is 3.98 m by 1.8 m (13 ft 1 inch by 5 ft 10 inches) and rises approximately 45.7 cm (1 ft 6 inches) above ground surface. Two 0.6 m (2 ft 3 inches) square metal openings which contained the sand pits extend through the top of the concrete. The top edge of the concrete is tapered at approximately 45 degrees. Two metal sheets that were used to seal the sand pits during the Smoky test are on the south side of the sand pit structure. One is leaning against the concrete and the other in partially buried by gravel. A 1.9 cm (3/4 inch) plywood and 2-x-4 wood frame has been constructed around the sand pit openings. Historic photographs taken after the Smoky test show no frames on the vent, therefore, the frame was added to the structure after the test. The concrete on the corners of the sand pit structure are cracked and deteriorating but it is otherwise intact.

The east air intake vent stack is intact and is connected to the base of the sand pit filtration structure at the west corner of the south side. The second air intake vent stack protrudes through the surface 5 m (16 ft 5 inches) west of the sand pit structure in the area that was excavated following the Smoky test. The 0.6 m (2 ft) square section of the air intake stack extends down 0.9 m (3 ft) and then tapers to a 0.6 m by 1.2 m (2 ft by 4 ft) rectangle. The top of the vent was blown off during the Smoky test and is absent. The concrete for the vent is cracked and deteriorating. A 0.6 m by 0.6 m (2 ft by 2 ft) broken section of one of the concrete exhaust

stacks is lying on the surface 2 m (6 ft 6 inches) south and 2 m (6 ft 6 inches) west of the east air intake stack. A 22.87 cm (9 inches) diameter pipe extends through both ends of the concrete stack. Both of the exhaust stacks for this shelter broke off from their original positions during the Smoky test. According to historic photos taken shortly after the blast, this section of exhaust stack is lying in its original post-test location. Given its location, it is unclear which exhaust stack this section originally belonged to. The concrete stack section is cracked and deteriorating and the pipe is bent. The above ground portion of the second air exhaust stack is entirely absent which also fits with the post-test configuration of this shelter. The base of the east exhaust stack at ground level is visible but the base of the west exhaust stack is buried under gravel.

S909 is the French underground rectangular concrete personnel Shelter II-5 (Station 8-30.6-8003) (DOE 1957). It is at UTM coordinate 582780 E, 4115531 N (Zone 11 NAD27) (Figures 105 and 106). Shelter II-5 was placed 321 m (1,053 ft) from the Smoky ground zero, at a location with a predicted overpressure of 118 psi. The shelter was 13 m (43 ft) south of the east-west line of the other structures and 24 m (79 ft) southeast of Shelter II-1 (S908).

The current condition of Shelter II-5, designated S909, matches the location and general description provided in Cohen and Dobbs (1962). The only portions of the structure visible on the surface are the entryways and the concrete ventilation stacks. The antechamber is underground and not accessible. The rectangular east and west entrances are 3.91 m (12 ft 10 inches) long by 1.62 m (5 ft 4 inches) wide, are 4.58 (15 ft) apart, and the long axis is aligned east-west. Stairs extend down from the entrances to the underground structure. The concrete on the entrances is cracked. The two concrete ventilation stacks for the structure are both 0.6 m (2 ft) square. The air exhaust vent stack is 1.3 m (4 ft 3 inches) west and 1 m (3 ft 3 inches) south of the west entrance and still attached to the underground structure. A 22.87 cm (9 inches) diameter pipe extends through the concrete and is cut flush with the top. A 0.6 m (2 ft) long section of the air intake vent stack is 2 m (6 ft 6 inches) south of the first vent. It has been broken off of the underground structure and is lying on the surface. The end of the air intake pipe still attached to the underground shelter can be seen protruding through the ground surface. The concrete on both of the vent stacks is broken and deteriorating. The ground between the two entrances appears to have been excavated sometime after the test. This was probably done to access the antechamber to investigate structural damage resulting from the test. The excavation was partially refilled. A round diagonal brace that was thrown a considerable distance from the Smoky tower during the blast is near the structure.

S910 is the French underground rectangular concrete personnel Shelter II-2 (Station 8-30.6-8002) (DOE 1957). It is at UTM coordinate 582798 E, 4115548 N (Zone 11 NAD27) (Figures 107 and 108). Shelter II-2 is the eastern French underground shelter and is 47 m (154 ft) east of Shelter II-1 (S908) and 34 m (112 ft) west of German underground shelter RAc (S914). Shelter II-2 was placed 308 m (1,010 ft) from the Smoky ground zero, at a location with a predicted overpressure of 132 psi.

The current condition of Shelter II-2, designated S910, matches the location and general description provided in Cohen and Dobbs (1962). The portions of the structure visible on the surface are the ventilation exhaust stack, emergency-exit shaft, the concrete structure containing the sand pit filtered air system, and the main entrance shaft. The entrance antechamber, main

chamber body, and emergency-exit chamber are underground and not accessible. The main entrance shaft and the concrete sand pit air filtration structure are located on a 5.79 m x 2.28 m (19 ft x 7 ft 6 inches) concrete pad at the west end of the underground structure. The sand pit air filtration system structure measures 2.13 m x 2.13 m (7 ft x 7 ft) and 0.6 m (2 ft) in height. A 0.6 m (2 ft) square opening that contained the sand pit is located in the center of the concrete structure. The opening is surrounded by a plywood and 2-x-4 wood frame attached to concrete with metal clips. The concrete from the top of the sand pit structure was built so that it rolls over to meet the concrete at the south end of the main entrance shaft. The concrete around the edges of the sand pit filter structure is broken and rebar is exposed. The main entrance shaft on the north end of the pad measures 0.71 m x 1.8 m (2 ft 4 inches x 5 ft 10 inches). The opening is surrounded by 2-x-4 and 2-x-6 framing.

A second concrete pad containing the emergency-exit shaft and cylindrical ventilation exhaust stack is located 10.17 m (33 ft 4 inches) east of the sand pit filter structure. The concrete pad measures 3.66 m (12 ft) long x 2.4 m (8 ft) wide. The emergency-exit shaft is near the southwest corner of the pad and consists of a 0.6 m (2 ft) square opening surrounded by a plywood and 2-x-4 in wood frame. The cylindrical ventilation exhaust stack is located on the north side of the concrete pad. It is 0.91 m (3 ft) in diameter across the top, 1.07 m (3 ft 6 inches) across the bottom, and is 1.27 m (4 ft 2 inches) tall. Rebar is exposed at the top of the stack. The concrete of both the exhaust stack and concrete pad is cracked and deteriorating. Historic photographs taken after the Smoky test show no wood frames around the sand pit filter opening, emergency-exit, or main entrance shaft; therefore, the frames were added to the structure sometime after the test. The ground near the entrance appears to have been excavated sometime after the test. This was probably done to access the underground portions of the shelter to investigate structural damage resulting from the test. The excavation was partially refilled.

Figure 99. S906, French underground personnel shelter II-4, view northeast (2012).

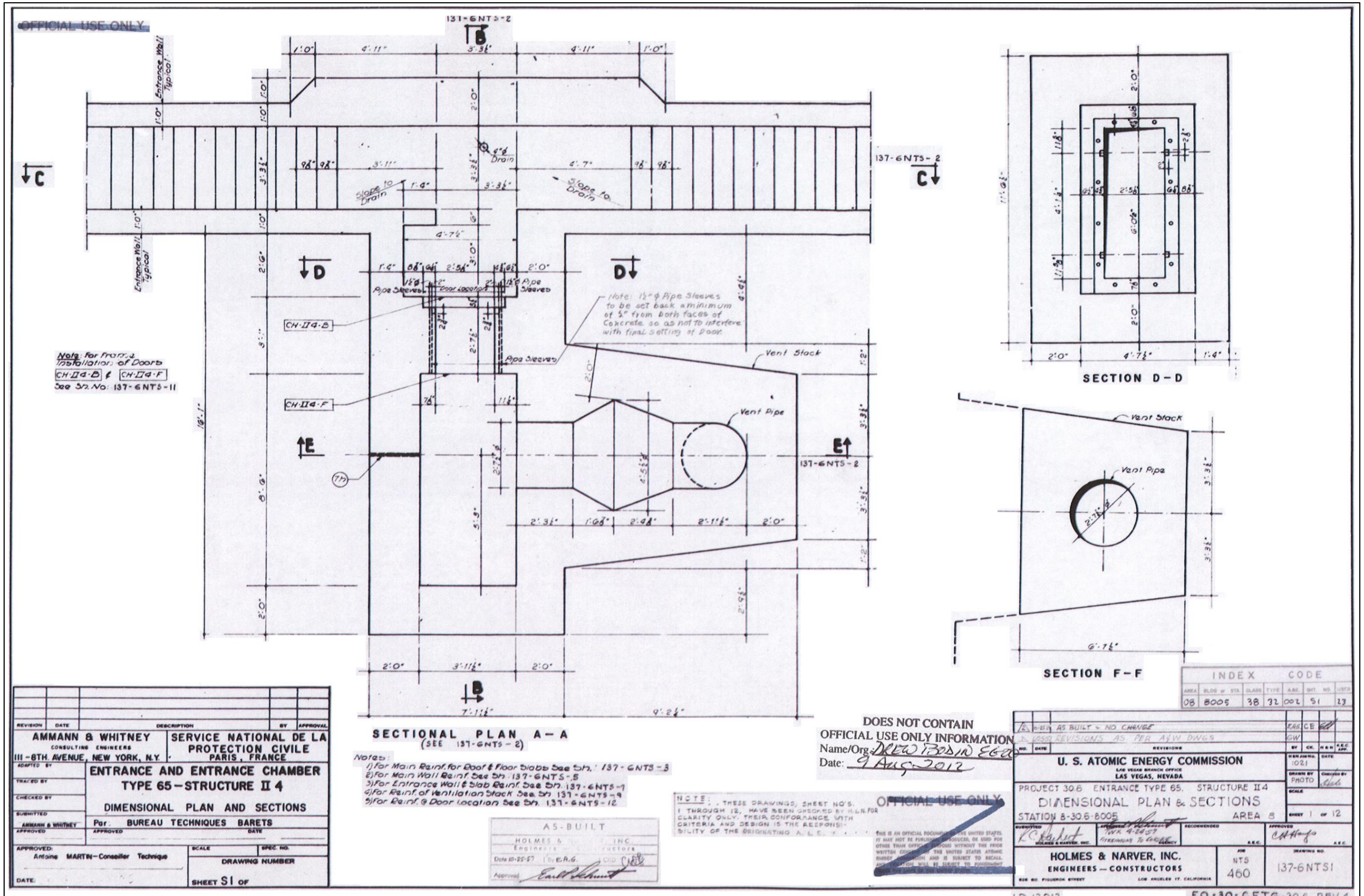


Figure 100. S906, French underground personnel shelter dimensional plan and sections.

Figure 101. S907, French underground personnel shelter II-3, view northeast (2012).

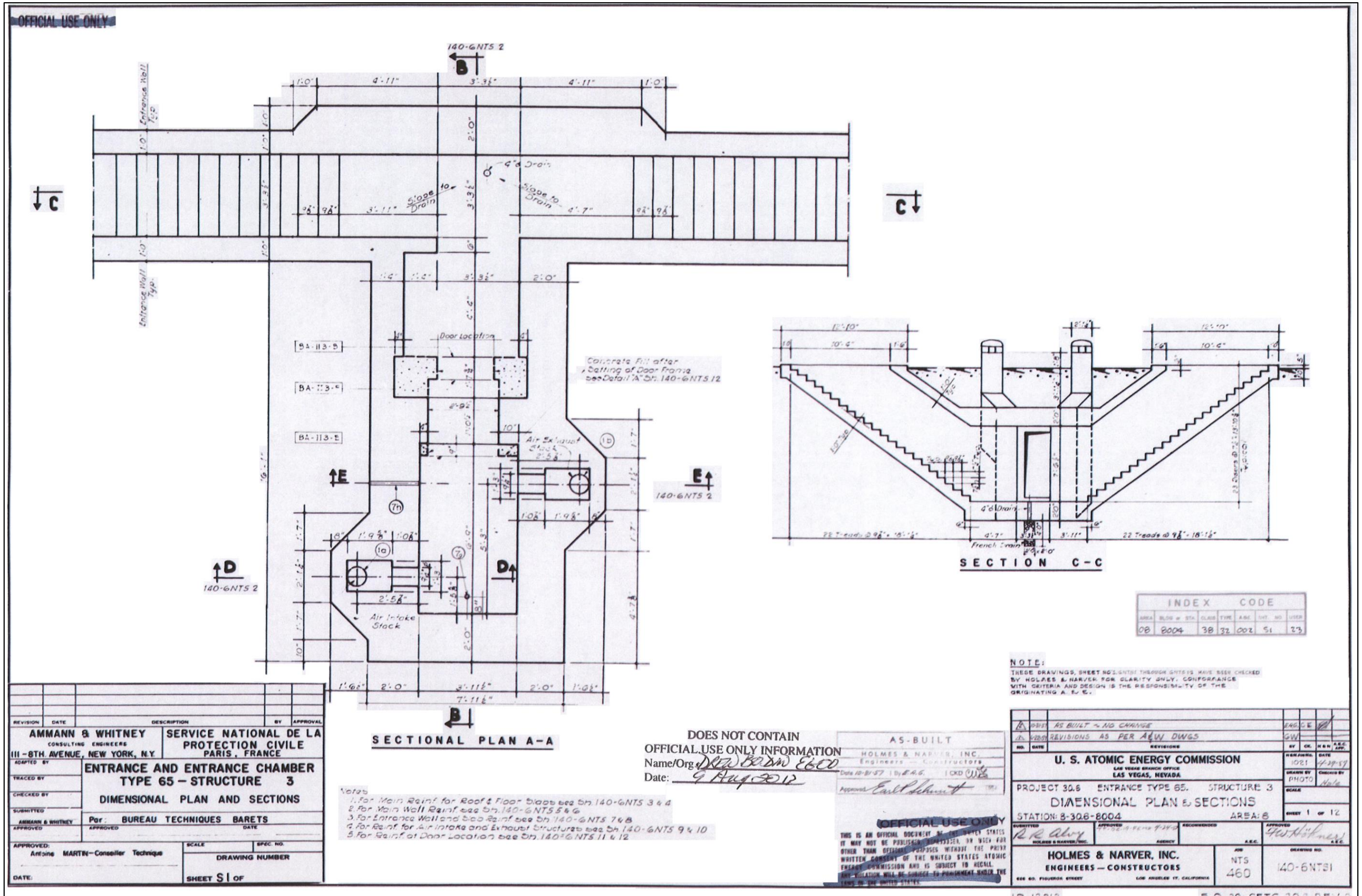


Figure 102. S907 French underground personnel shelter II-3.

Figure 103. S908, French underground personnel shelter II-1, view east (2012).

Figure 104. S908, French underground personnel shelter II-1 after the Smoky test, view southeast, (1957, photograph 57-195 on file at the NNSA/NFO Nuclear Testing Archive, Las Vegas, Nevada).

Figure 105. S909, French underground personnel shelter II-5, view southeast (2012).

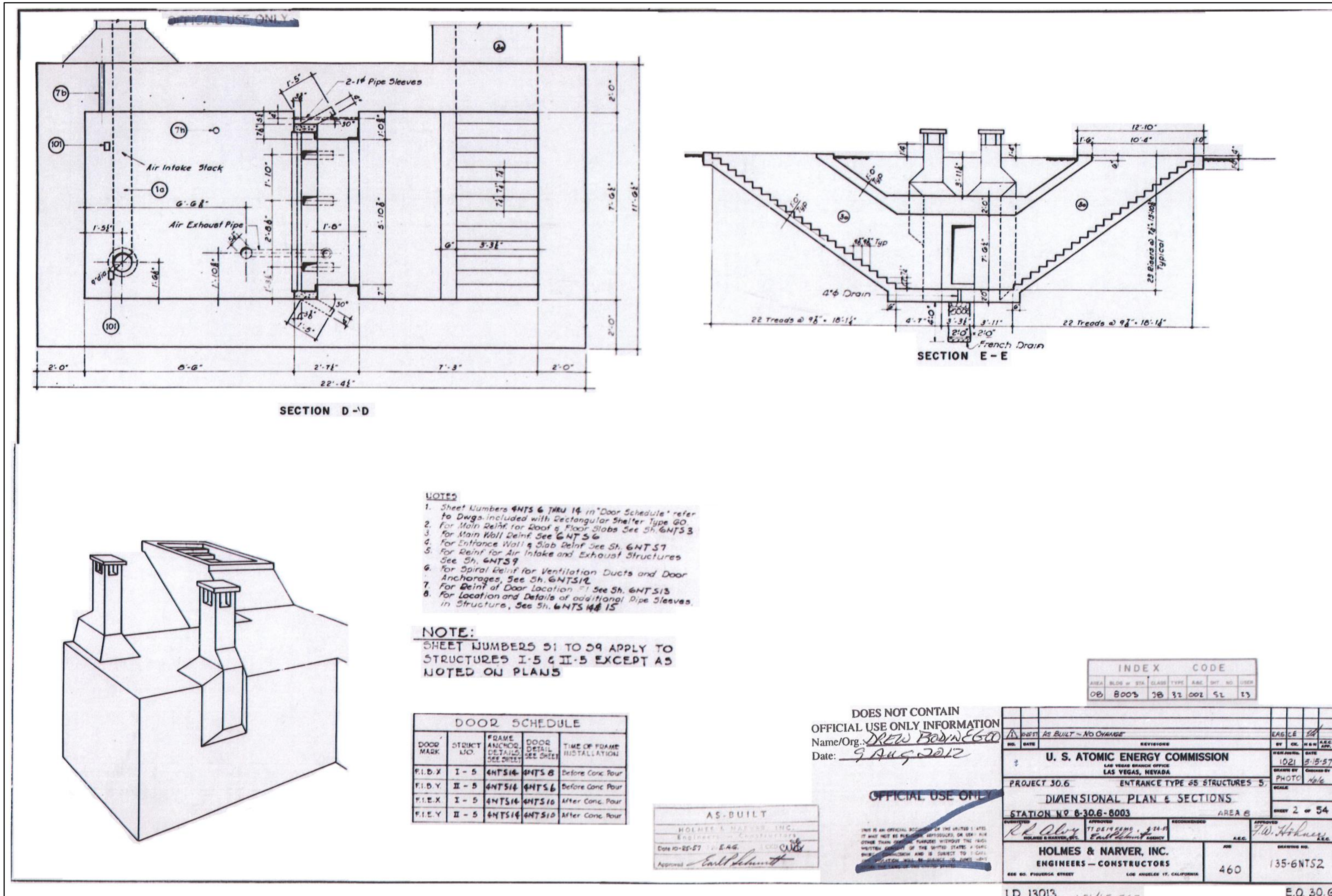


Figure 106. S909, French underground personnel shelter II-5.

Figure 107. S910, French underground personnel shelter II-2 entrance (black arrow) and vent stack (white arrow), view southeast (2012).

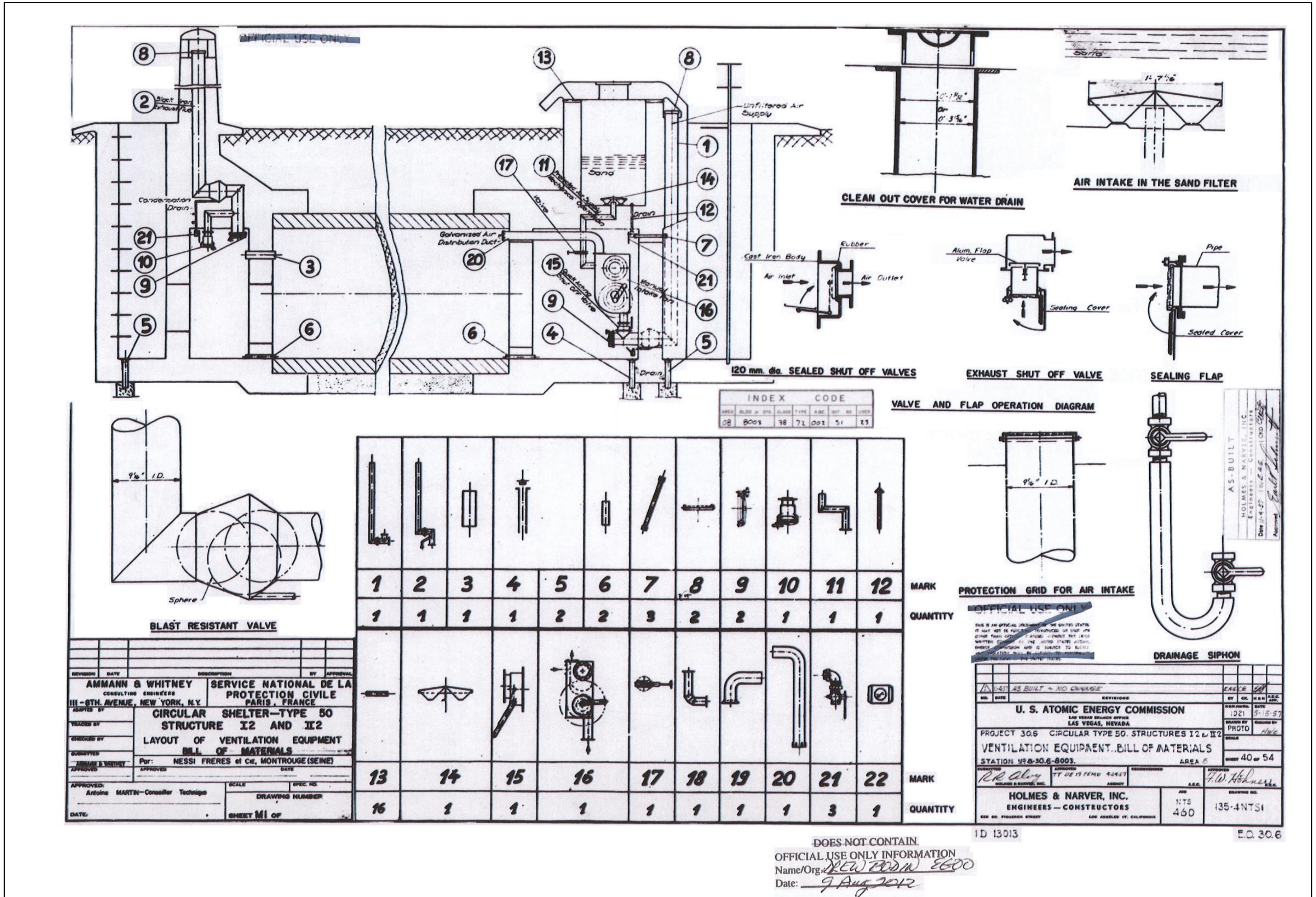


Figure 108. S910, French underground personnel shelter II-2.

German Personnel Shelters: S911, S912, S913, S914, S915, S916, S917, S918, S923 (Exit Shaft and Vent Stack from S918)

S911 is the German underground rectangular concrete personnel Shelter RAa (Station 8-30.7-8008) (DOE 1957). It is at UTM coordinate 582831 E, 4115608 N (Zone 11 NAD27) (Figures 109 and 110). Shelter RAa is 15 m (49 ft) north of Shelter RAb (S912). It was placed 256 m (840 ft) south of the Smoky ground zero, at a location with a predicted overpressure of 264.6 psi.

The current condition of Shelter RAa, designated S911, matches the location, engineering drawings, and general description provided in Cohen and Bottenhofer (1962). The only portions of the structure visible on the surface are the entryways and the concrete ventilation stack. The entrance vestibule, main shelter body, exit chamber, emergency-exit tunnel, and emergency-exit shaft are underground, not accessible, and not visible from the surface. The two entrances are rectangular and each is 6.4 x 2.18 m (21 ft x 7 ft 2 inches). The south entrance contains concrete stairs and the north entrance is a concrete ramp. Both entrances are partially filled with tumbleweeds and the concrete is cracked along the top edge and the entrance walls of the entrances. The 1.52 x 1.52 m (5 x 5 ft) concrete ventilation shaft is 9.8 m (32 ft 2 inches) east of the entrances. The ventilation shaft opening on the surface is 61 cm x 61 cm (2 x 2 ft) and near the northeast corner. A 2-x-4 and plywood frame is attached to the concrete with clips. Historic photographs taken after the Smoky test show no frames on the vent, therefore, the frame was added to the structure after the test. The opening extends into the concrete 10 cm (4 inches) and then reduces in size to 40 cm (1 ft 4 inches). At the northwest edge of the vent is a 1.21 m (4 ft) square concrete block that was used to seal the vent. Four eye bolts along the edges of the block could be attached to cables to lift the block from the vent. The corners of the vent cover were broken off when it was removed from the vent shaft shortly after the Smoky test.

S912 is the German underground rectangular concrete personnel Shelter RAb (Station 8-30.7-8010) (DOE 1957). It is at UTM coordinate 582835 E, 4115591 N (Zone 11 NAD27) (Figures 110 and 111). Shelter RAb is 15 m (49 ft) south of Shelter RAa (S911), 30 m (98 ft) north of Shelter RAc (S914), and 30 m (98 ft) west of Shelter CAc (S913). It was placed 274.3 m (900 ft) south of the Smoky ground zero, at a location with a predicted overpressure of 198.5 psi.

The current condition of Shelter RAb, designated S912, matches the location, engineering drawings, and general description provided in Cohen and Bottenhofer (1962). The only portions of the structure visible on the surface are the entryways and the concrete ventilation shaft. The entrance vestibule, main shelter body, exit chamber, emergency-exit tunnel, and emergency-exit shaft are underground, not accessible, and not visible from the surface. The two entrances are rectangular and each is 6.4 m by 2.18 m (21 ft by 7 ft 2 inches). The south entrance contains concrete stairs and the north entrance is a concrete ramp. The concrete is cracked along the top edge and walls of the entrances to the underground shelter. The 1.52 m by 1.52 m (5 ft by 5 ft) concrete ventilation shaft is 9.8 m (32 ft 2 inches) east of the entrances. The ventilation shaft opening on the surface is 61 cm by 61 cm (2 ft by 2 ft) and near the northeast corner. The opening extends into the concrete 10 cm (4 inches) and then reduces in size to 40 cm (1 ft 4 inches). At the northwest edge of the vent is a 1.21 m (4 ft) square partially-buried concrete block cover that was used to seal the vent. Eye bolts along the edges of the block could be

attached to cables to lift the block from the vent. The corners of the vent cover were broken off when it was removed from the vent shaft shortly after the Smoky test.

S913 is the German underground circular concrete personnel Shelter CAa (Station 8-30.7-8009) (DOE 1957). It is at UTM coordinate 582861 E, 4115601 N (Zone 11 NAD27) (Figures 112 and 113). Shelter CAa is 30 m (98 ft 7 inches) east of Shelter RAb (S912). It was placed 274.3 m (900 ft) south of the Smoky ground zero, at a location with a predicted overpressure of 198.5 psi.

The current condition of Shelter CAa, designated S913, matches the location, engineering drawings, and general description provided in Cohen and Bottenhofer (1962). The only portions of the structure visible on the surface are the entranceway and the combination emergency-exit and ventilation shaft. The entrance vestibule, main shelter body, and emergency-exit chamber are underground and not accessible. The rectangular concrete entrance is 3.86 m x 1.82 m (12 ft 10 inches x 6 ft). The concrete entrance walls are cracked but not as much as in the shelters closer to ground zero. The combination emergency-exit and ventilation shaft is concrete and located 6.7 m (22 ft) west of the entrance. The concrete block for the combination emergency-exit and ventilation shaft is 1.21 x 1.21 m (4 ft x 4 ft) and the shaft opening is 0.62 m (2 ft 1/2 inch) square. A 2-x-4 and plywood frame is attached to the concrete with clips. Historic photographs taken after the Smoky test show no frames on the vent, therefore, the frame was added to the structure after the test.

S914 is the German underground rectangular concrete personnel Shelter RAc (Station 8-30.7-8011) (DOE 1957). It is at UTM coordinate 582842 E, 4115559 N (Zone 11 NAD27) (Figures 110 and 114). Shelter RAc is 30 m (98 ft 7 inches) south of Shelter RAb (S912) and 30 m (98 ft 7 inches) west of Shelter CAb (S915). It was placed 308 m (1,010 ft) south of the Smoky ground zero, at a location with a predicted overpressure of 132.3 psi.

The current condition of Shelter RAc, designated S914, matches the location, engineering drawings, and general description provided in Cohen and Bottenhofer (1962). The only portions of the structure visible on the surface are the entryways and the concrete ventilation shaft. The entrance vestibule, main shelter body, exit chamber, emergency-exit tunnel, and emergency-exit shaft are underground and not accessible. The two entrances are rectangular and each is 6.4 x 2.18 m (21 ft x 7 ft 2 inches). The south entrance contains concrete stairs and the north entrance is a concrete ramp. Both entrances are filled with tumbleweeds but the blast door for the south entrance is partially visible and open. The concrete entrance walls are cracked and the separation in the cracks is less than in the shelters closer to ground zero. The 1.52 m x 1.52 m (5 ft x 5 ft) concrete ventilation shaft is 9.8 m (32 ft 2 inches) east of the entrances. The ventilation shaft opening on the surface is 61 cm x 61 cm (2 ft x 2 ft) and near the northeast corner. The opening extends into the concrete 10 cm (4 inches) and then reduces in size to 40 cm (1 ft 4 inches). At the northeast edge of the vent is a 1.21 m (4 ft) square partially buried concrete block cover that was used to seal the vent. Eye bolts along the edges of the block could be attached to cables to lift the block from the vent. The corners of the vent cover were broken off when it was removed from the vent shaft shortly after the Smoky test.

S915 is the German underground circular concrete personnel Shelter CAb (Station 8-30.7-8012) (DOE 1957). It is at UTM coordinate 582868 E, 4115569 N (Zone 11 NAD27) (Figures 113 and 115). Shelter CAb is 30 m (98 ft 7 inches) east of Shelter RAc (S914). It was placed 308 m (1,010 ft) south of the Smoky ground zero, at a location with a predicted overpressure of 132.3 psi.

The current condition of Shelter CAb, designated S915, matches the location, engineering drawings, and general description in Cohen and Bottenhofer (1962). The only portions of the structure visible on the surface are the entranceway and the combination emergency-exit and ventilation shaft. The entrance vestibule, main shelter body, and emergency-exit chamber are underground and not accessible. The rectangular concrete entrance is 3.86 m x 1.82 m (12 ft 10 inches x 6 ft). The concrete entrance walls are cracked and the separation in the cracks is less than in the shelters closer to ground zero. The entranceway is partially filled with tumbleweeds. The combination emergency-exit and ventilation shaft is concrete and located 6.7 m (22 ft) west of the entrance. The concrete block for the combination emergency-exit and ventilation shaft is 1.21 x 1.21 m (4 ft x 4 ft) and the shaft opening is 0.62 m (2 ft 1/2 inch) square. A 2-x-4 and plywood frame is attached to the concrete with clips. Historic photographs taken after the Smoky test show no frame on the vent, therefore, the frame was added to the structure after the test.

S916 is the German underground rectangular concrete personnel Shelter RAd (Station 8-30.7-8013) (DOE 1957). It is at UTM coordinate 582854 E, 4115508 N (Zone 11 NAD27) (Figures 110 and 116). Shelter RAd is 45 m (148 ft) south of Shelter RAc (S914). It was placed 358.5 m (1,176 ft) south of the Smoky ground zero, at a location with a predicted overpressure of 88.2 psi.

The current condition of Shelter RAd, designated S916, matches the location, engineering drawings, and general description provided in Cohen and Bottenhofer (1962). The only portions of the structure visible on the surface are the entryways and the concrete ventilation shaft. The entrance vestibule, main shelter body, exit chamber, emergency-exit tunnel, and emergency-exit shaft are underground, not accessible, and not visible from the surface. The two entrances are rectangular and each is 6.4 m x 2.18 m (21 ft x 7 ft 2 inches). The south entrance contains concrete stairs and the north entrance is a concrete ramp. The 1.52 m x 1.52 m (5 ft x 5 ft) concrete ventilation shaft is 9.8 m (32 ft 2 inches) east of the entrances. The ventilation shaft opening on the surface is 61 cm x 61 cm (2 ft x 2 ft) and near the northeast corner. The opening extends into the concrete 10 cm (4 inches) and then reduces in size to 40 cm (1 ft 4 inches). A 2-x-4 and plywood frame is attached to the concrete with clips. Historic photographs taken after the Smoky test show no frames on the vent, therefore, the frame was added to the structure after the test. At the northeast edge of the vent is a 1.21 m (4 ft) square partially buried concrete block cover that was used to seal the vent. Eye bolts along the edges of the block could be attached to cables to lift the block from the vent. The concrete entrance walls are cracked and the separation in the cracks is less than in the shelters closer to ground zero. The corners of the vent cover were broken off when it was removed from the vent shaft shortly after the Smoky test.

S917 is the German underground rectangular concrete personnel Shelter RCa (Station 8-30.7-8014) (DOE 1957). It is at UTM coordinate 582895 E, 4115331 N (Zone 11 NAD27) (Figures 117-119). Shelter RCa is 175 m (574 ft) south of Shelter RAd (S916). It was placed

539.5 (1,770 ft) south of the Smoky ground zero, at a location with a predicted overpressure of 29.4 psi.

The current condition of Shelter RCa, designated S917, matches the location, engineering drawings, and general description in Cohen and Bottenhofer (1962). The double entranceway is the only visible portion of the structure. The entrance vestibule, main body, exit chamber, and emergency-exit tunnel are underground and not accessible. The rectangular concrete entrance is 15.24 (50 ft) in length by 2.03 m (6 ft 8 inches) in width. The north side of the entrance is a ramp and the southern side is stairs. The walls are 29.84 cm (11 3/4 inches) thick. The concrete is in relatively good condition with no cracks seen on the top edge or walls of the entrance. The entranceway is partially filled with tumbleweeds and the entrance blast door is open and partially visible. The combination emergency-exit shaft and vent stack could not be located in the field and is probably completely covered with alluvium.

S918 is the German underground rectangular concrete personnel Shelter RCb (Station 8-30.7-8015) (DOE 1957). It is at UTM coordinate 582940 E, 4115135 N (Zone 11 NAD27) (Figures 118-120). Shelter RCb is 194.5 m (638 ft) south of Shelter RCa (S917) and 35 m (115 ft) west of the Ballistic Research Laboratories Structure (S919). It was placed 740.6 m (2,430 ft) south of the Smoky ground zero, at a location with a predicted overpressure of 14.7 psi.

The current condition of Shelter RCb, designated S918, matches the location, engineering drawings, and general description provided in Cohen and Bottenhofer (1962). The only portions of the structure visible on the surface are the double entranceway and the combination emergency-exit shaft and vent stack. The entrance vestibule, main body, exit chamber, and emergency-exit tunnel are underground and not accessible. The rectangular concrete entranceway is 15.24 m (50 ft) long by 2.03 m (80 inches) wide. The north side of the entranceway is a ramp and the south side is stairs. The walls are 29.84 cm (11 3/4 inches) thick and the concrete is not cracked or broken around the top edge or the entrance walls. The only part of the emergency-exit shaft and vent stack visible at the surface is the 0.9 m x 0.9 m (3 ft x 3 ft) metal hatch opening. This was not recognized as part of the shelter until after structure numbers were assigned so the exit shaft was originally designated as a separate resource, S923. Wood (2-x-4s) from a frame added after the Smoky test is also partially visible around the emergency-exit shaft opening.

S923 is the emergency-exit shaft and vent stack for German shelter S918 (Station 8-30.7-8015) (Figure 121). It is at UTM coordinate 582940 E, 4115135 N (Zone 11 NAD27). The only portion visible at the surface is a 0.9 m x 0.9 m (3 ft x 3 ft) hatch frame. S923 was initially recorded as a separate structure and it was not recognized as part of the underground shelter S918 until after structure numbers were assigned. Engineering drawings from Cohen and Bottenhofer (1962) indicate the portion of shelter S918 that was originally designated as S923. The full description of this component of the German shelter is included under the S918 description.


Figure 109. S911, German underground personnel shelter RAa entrances, view southeast (2012).

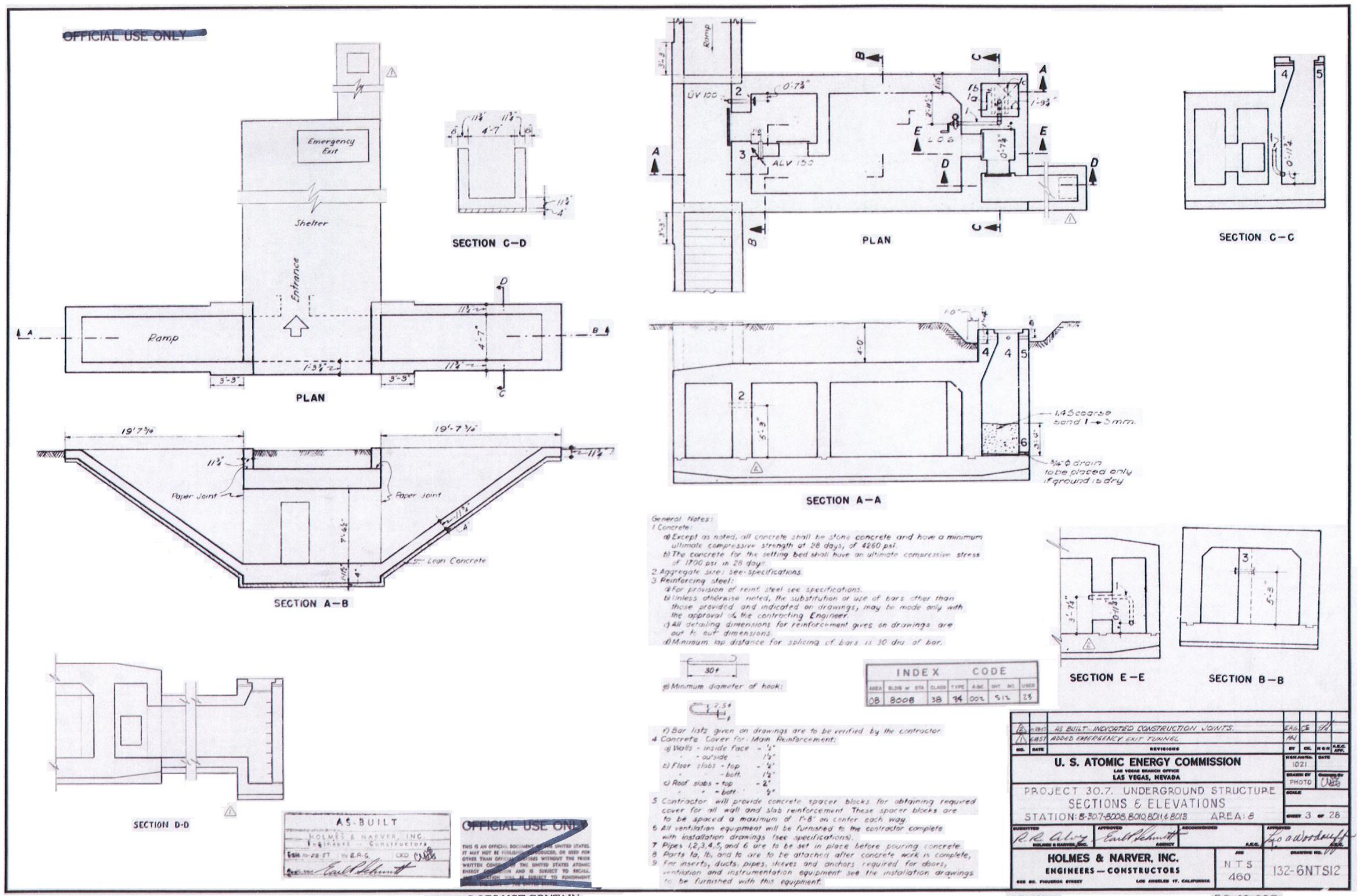


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Figure 110. S911, S912, S914, S916, German underground personnel shelters RAa, RAb, RAc, RAd, sections and elevations.

Figure 111. S912, German underground personnel shelter RAb, view southeast (2012).


Figure 112. S913, German underground personnel shelter CAa, view east (2012).

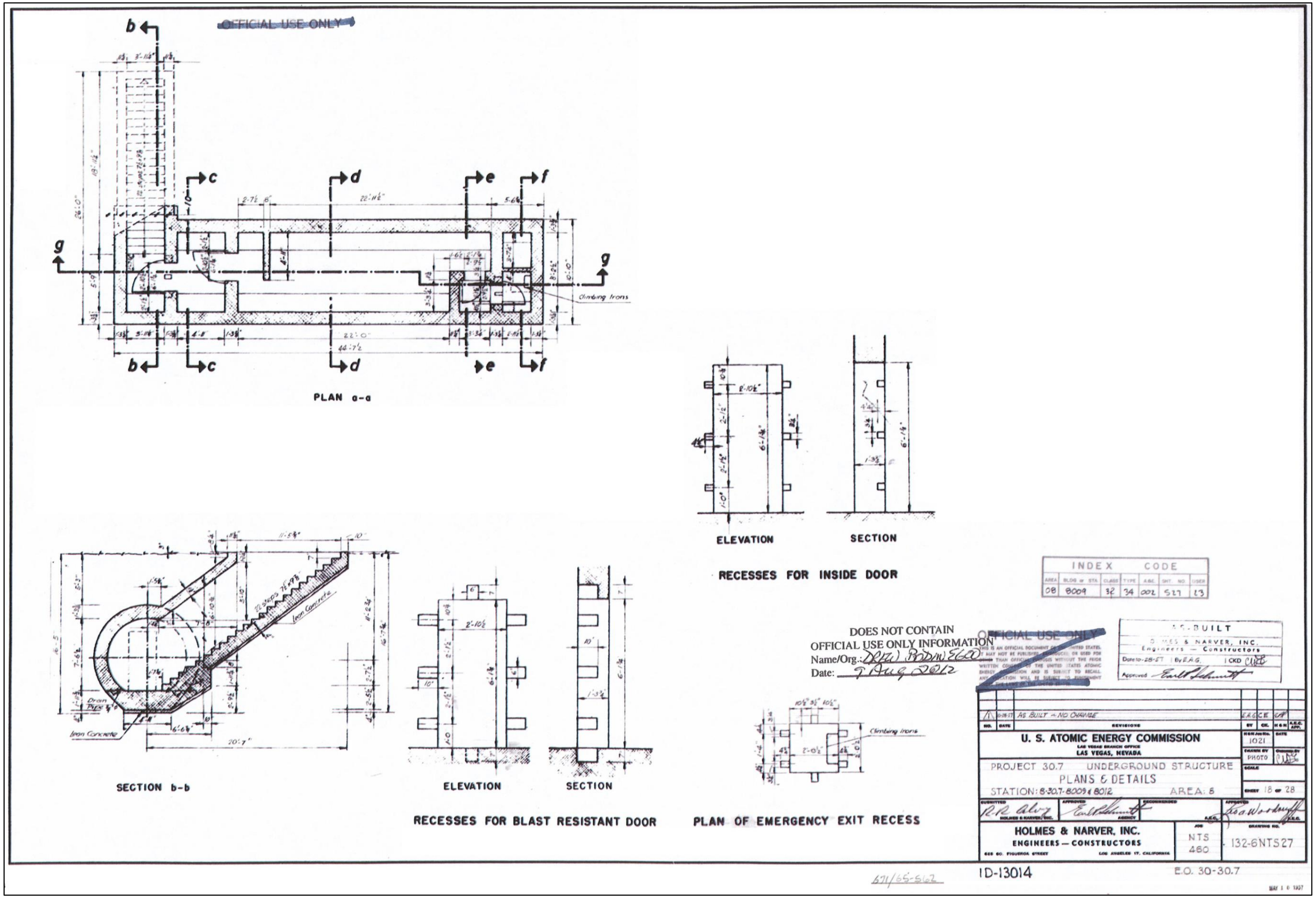

Figure 113. S913 and S915, German underground personnel shelters CAa and CAb, plans and details.


Figure 114. S914, German underground personnel shelter RAc entrances, view north (2012).

Figure 115. S915, German underground personnel shelter CAb, view southeast (2012).

Figure 116. S916, German underground rectangular concrete personnel shelter RAd,view southwest (2012).


Figure 117. S917, German underground personnel shelter RCa entrance, view southeast (2012).

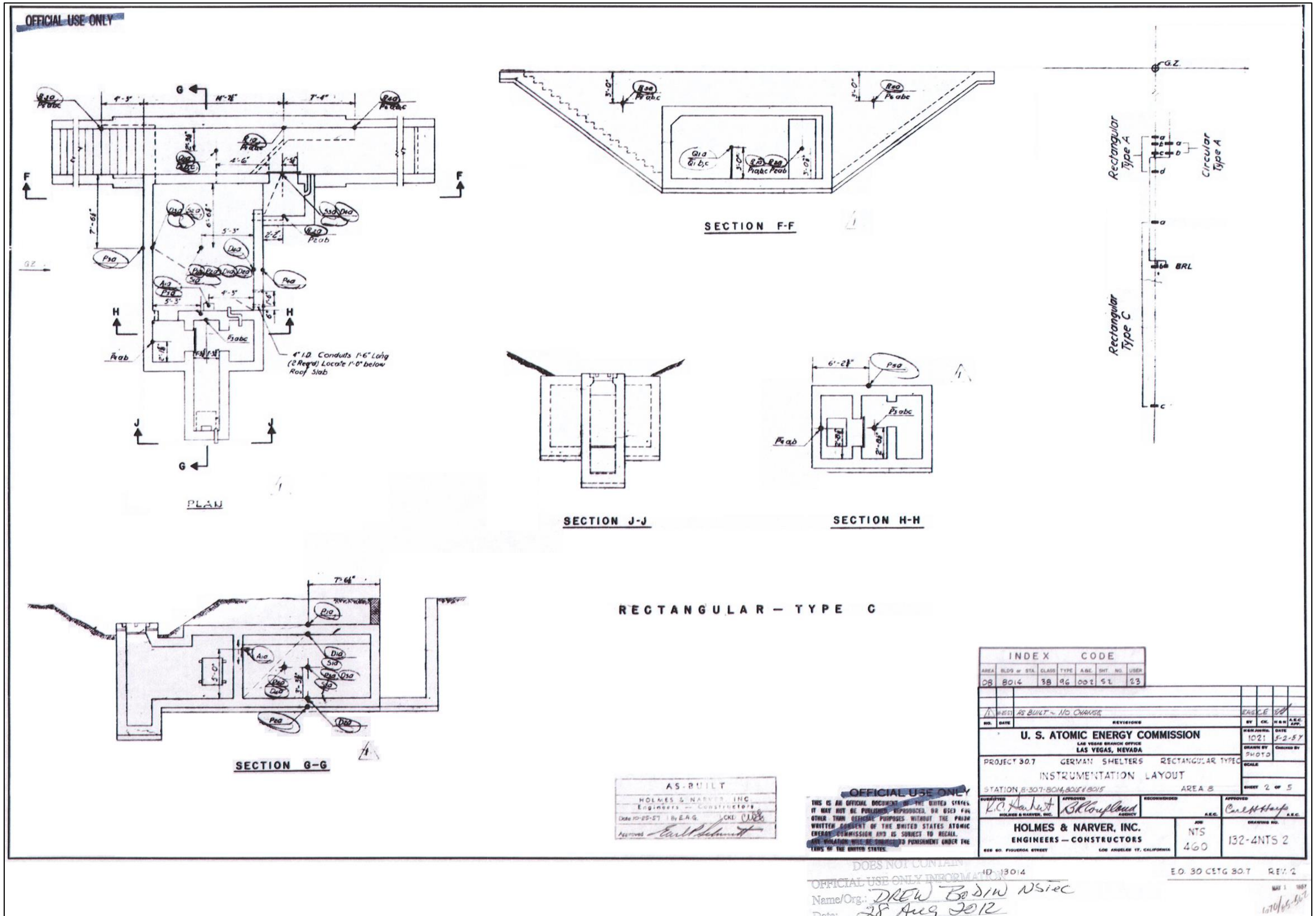

Figure 118. S917 and S918, German underground personnel shelters RCa and RCb, plan and sections.

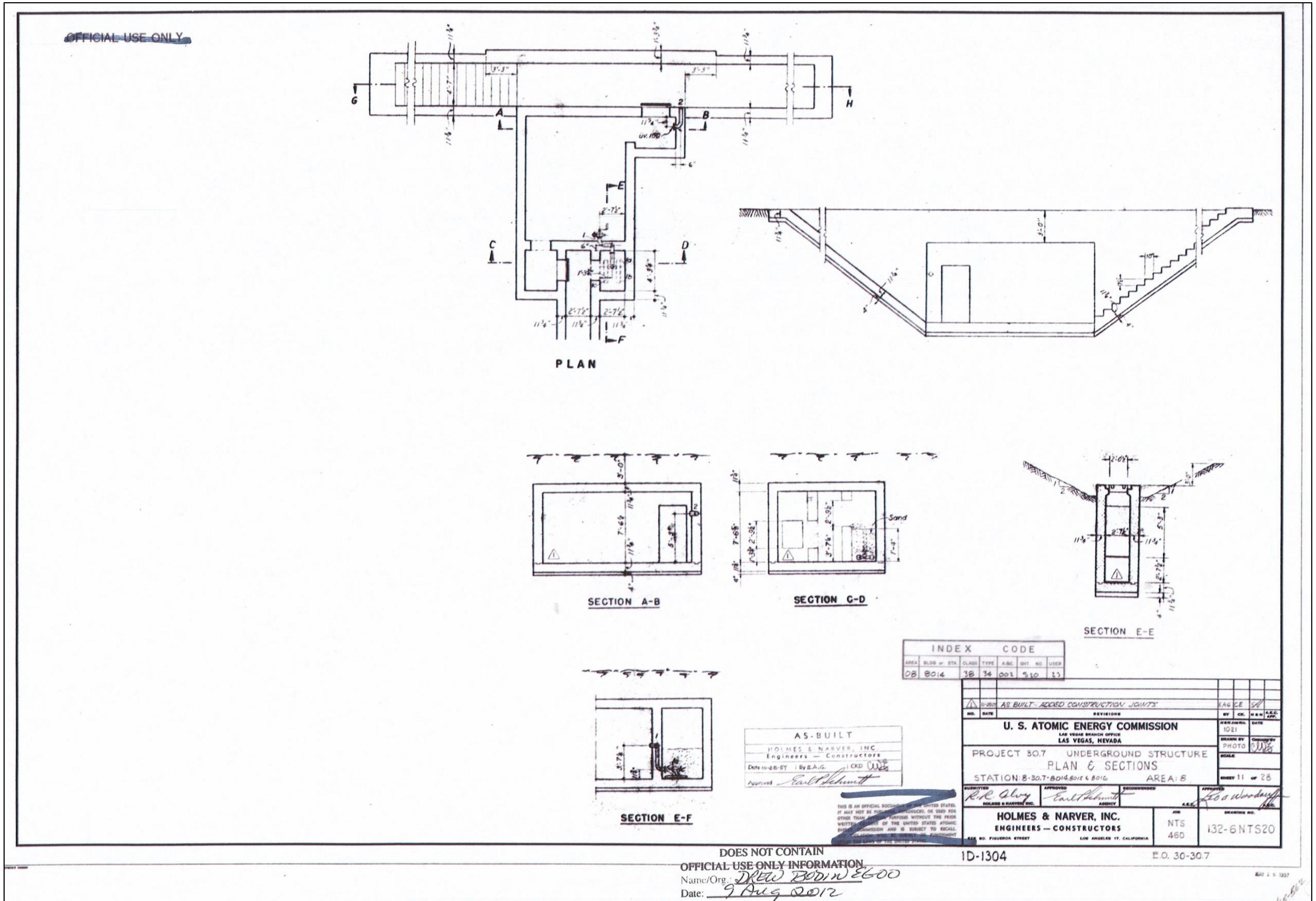

Figure 119. S917 and S918, German underground personnel shelters RCa and RCb, plan and sections.

Figure 120. S918, German underground personnel shelter RCb entrance, view southeast (2012).

Figure 121. S918, emergency-exit shaft and vent stack of S918 (designated S923), view southwest (2012).

Ancillary Structures

Trailer

B12411 is a collapsed trailer at UTM coordinate 582929 E, 4115942 N (Zone 11 NAD27) (Figure 122). The trailer is located 200 m (656 ft) east of ground zero of the Smoky test. It measures approximately 2.44 m x 11 m (8 ft x 36 ft). It has been flipped on its roof which caused the collapse of the walls. The trailer has a metal frame and the walls were 2-x-2 milled lumber studs and plywood sheeting. The outside of the trailer was wrapped in aluminum panels. The attached license plate is "U.S. Government E-26307" and a metal plate near the trailer frame has the words "TRAILER 124-N." This trailer is not associated with the Smoky atmospheric nuclear test, but rather with more recent activities in the area.

Electrical Panel and Backboard

S901 is an electrical panel and backboard at UTM coordinate 583000 E, 4115952 N (Zone 11 NAD27) (Figure 123). S901 is 78 m (256 ft) east of the collapsed trailer (B12411). The electrical panel is 81.3 x 45.7 x 15.2 cm (2 ft 8 inches x 2 ft 6 inches x 6 inches). The panel door is locked and conduit and electrical cables extend though the bottom of the box and underground. The backboard is 1.2 x 1.2 m (3 ft 11 inches x 3 ft 11 inches) and is supported by two 4-x-4 posts, 1.6 m (5 ft 4 inches) in length. The backboard is no longer in an upright position and is lying on the surface. The posts are not broken or rotted. The structure is not part of the Smoky atmospheric nuclear test as an upright plywood construction would not survive overblast pressure from a nuclear detonation. S901 was probably used for later activities in the area.

Concrete Pad

S902 is a concrete pad at UTM coordinate 583082 E, 4115890 N (Zone 11 NAD27) (Figure 124). No engineering drawings or descriptions of the concrete pad were located during archival research. The concrete pad is 340 m (1,115 ft) east of ground zero and 40 m (131 ft) north of S903, a concrete battery vault. It is 3.05 m x 1.82 m (10 ft x 5 ft 11 1/2 inches). No measurement of thickness was obtained in the field. The concrete pad has four 27.9 cm x 27.9 cm (11 x 11 inches) square cutouts in the surface near the south end. Three cutouts contain 1-x-6 wood frames and one contains no frame. Four 1.9 cm (3/4 inch) diameter anchor bolts are in a rectangular pattern between the cutouts. The two bolts on the western portion of the side have attached nuts. Next to the east side of the pad is a 96.5 cm (3 ft 2 inches) long 1-x-3 piece of milled lumber. The board is partially buried in alluvium and protruding through the side of the board are two bolts. The concrete pad once supported an unknown piece of equipment.

Electrical Switch Boxes and Backboard

S905 consists of an electrical panel backboard, two electrical switch boxes, and one electrical transformer at UTM coordinate 582786 E, 4115741 N (Zone 11 NAD27) (Figure 125). The structure is 116 m (380 ft) south of ground zero. The backboard is a 1.2 m x 0.91 m (4 ft x 3 ft) piece of ¾-inch plywood attached to two 2-inch angle iron posts. The bottom edge of the plywood backboard is on the surface. Diagonal angle iron braces support the posts. One of the electrical switch boxes is mounted on to the backboard and the other is lying on the surface. The boxes are 35.6 cm x 20.3 cm x 7.6 cm (1 ft 2 inches x 8 inches x 3 inches.) The transformer is octagonal in shape and approximately 30 cm x 25 cm (10 inches x 8 inches.) Next to the east side of the backboard is an electrical outlet with attached cable lying on the surface. The structure is not part of the Smoky atmospheric nuclear test and was used for later activities in the area.

Figure 122. B12411, trailer, view west (2012).

Figure 123. S901, electrical panel and backboard, view west (2012).

Figure 124. S902, concrete pad, view north (2012).

Figure 125. S905, electrical switch boxes and backboard, view northwest (2012).

SMOKY MILITARY TRENCHES (D104 and 26NY14795)

The site boundary for 26NY14795 encompasses seven trenches built for military training during the Smoky test (S922). No artifacts or features were recorded in the site area; however, there is potential for buried cultural materials in the partially filled trenches.

Military Trenches

S922 consists of seven military trenches located 4.3 km (2.7 miles) southeast of the ground zero for the Smoky atmospheric nuclear test at UTM coordinate 584846 E, 4112018 N (Zone 11, NAD27).

As discussed in the Historic Context section (pages 69-73), Task Force BIG BANG, Task Force WARRIOR, and Program 50.2- Troop-Observer Indoctrination were associated with the Smoky atmospheric nuclear test. Military trenches (S922) dug by the 84th Engineer Construction Battalion to a depth of 1.8 m (6 ft) deep were to be used in association with these projects (Baldwin 1958). However, due to concerns about radiation exposure based on unfavorable wind forecasts, the trenches were unused except for an infiltration course located 1,372 m (4,498 ft) north of the trenches and 3,017 m (9,898 ft) south of ground zero. The infiltration course was utilized as part of Task Force BIG BANG after a rifle disassembly/reassembly exercise was performed by troops immediately after witnessing the Galileo test on September 2, 1957 (Harris et al. 1981a, 1981b).

S922 is easily identified in an aerial image (Figure 45) and matches the location provided in Baldwin (1958). On the aerial image the trenches appear as seven parallel and equally spaced linear features running from southwest to northeast. Historical schematics show five trenches, four long trenches to station military troops and one shorter trench for VIPs (Baldwin 1958). On the aerial image four long trenches and three short trenches can be discerned. The reason for the discrepancy between historical schematics showing five trenches and the current configuration of seven trenches is unknown. The trenches are within a 460 m by 170 m (1,509 ft by 557 ft) area. The four long trenches are approximately 439 m (1,440 ft) long and are spaced 30.5 m (100 ft) apart. North of these are two short trenches, 42 m (138 ft) long and 32 m (105 ft long). South of the long trenches is a third short trench approximately 23 m (75 ft) long. A two-track road crosses the west end of the long trenches at an oblique angle.

All seven of the trenches were recorded during field survey. The four long trenches are straight, shallow features with no obvious berms (Figure 126). They occur in an area of relatively even terrain with a gentle southern grade. Originally, the trenches were about 6 ft deep, but now are no more than 90 cm (3 ft) deep. The trenches have either been partially filled by sedimentation from erosion and natural alluvial processes, backfilled sometime after the Smoky test, or both. The absence of sediment berms from the original construction would suggest some degree of backfilling. However, the exposed sides of the trenches have U-shaped profiles suggesting erosion and sedimentation are active. The short trenches have sediment berms. These trenches are no more than 90 cm (3 ft) deep; however, are more pronounced than the long trenches due to sediment berms along their lengths. Erosion and alluvial processes are filling the trenches with alluvial materials.

Figure 126. S922, Smoky “long” military trench, view northeast (2012).

SUMMARY AND RECOMMENDATIONS

This cultural resources study of the Smoky test area was initiated due to the development of a Corrective Action Investigation Plan to study the Smoky atmospheric test location for hazardous and/or radioactive contaminants that may be present in concentrations exceeding risk-based corrective action levels. Based on the results of the investigation, there are several corrective action alternatives that are considered: no further action, closure in place, and clean closure. Corrective action investigations and corrective action decisions are undertakings that might have adverse effects on the cultural resources in the Smoky test area.

The Smoky nuclear test was a 44 kt test detonated on top of a 213.4 m (700 ft) 200-ton tower (T-2c) on August 31, 1957. Smoky was a weapons related test of the Plumbbob series (number 19) and part of the DOD Exercise Desert Rock VII and VIII. The AEC was the directing agency and conducted 16 separate scientific and diagnostic experiments and 22 research projects for the safety of civilians. The DOD conducted 10 military research projects and French and German scientists participated in the design and testing of underground personnel structures. Desert Rock troops were participants in exercises to develop tactics for the nuclear battlefield. More than 3,500 personnel participated in the Smoky test. Later, due to the excess incidence of leukemia among these veterans, a study of mortality by cause of death was done on 46,186 participants in Operations Upshot-Knothole, Plumbbob, Greenhouse, Castle, and Redwing. The Medical Follow-up Agency of the National Research Council has continued to maintain this program.

The focus of this study was the cultural resources inventory and historical evaluation of the Smoky test location. Through archival historical research and field documentation, it was determined the test area includes a series of significant structures and two historic archaeological sites (26NY14794 and 26NY14795) linked by the theme of the Smoky atmospheric nuclear test and designated historic district D104. The two archaeological sites, the Smoky test area and the military trenches, are spatially discrete with a distance of 3.8 km (2.1 mi) between them. As a result, D104 is a discontiguous historic district.

The total area for historic district D104 is 151.4 hectares (374 acres) and coincides with the area of historic sites 26NY14794 and 26NY14795. The area for historic site 26NY14794, the Smoky test area, is 140 hectares (346 acres) of which the 51 hectares (126 acres) within the APE were inventoried. The entire site area was not examined due to radiological and time constraints. Within the inventoried site area, DRI recorded 1 building (a trailer not associated with the Smoky test), 37 structures, and 14 features. Of the 37 structures, 35 contribute to the historic district. These are the remaining elements of the tower (tower foundation, stanchions, elevator pit, and hoist foundation), instrument stations, underground personnel shelters, and a battery vault. Features are vent stack sections, concrete pads, concrete blocks, a charcoal concentration, and a wood box. Artifacts (n=1,308) are the structural round and square metal tower legs and tension rods, an elevator winch drum and reducer gears, metal fragments, charcoal briquettes, wood, lead bricks, glass, braces, cable, concrete, rebar, and other metal fragments. Historic site 26NY14795, the military trenches (S922), is 4.37 km (2.7 miles) southeast of the Smoky ground

zero. The site is 11.4 hectares (28 acres) and consists of a series of seven parallel linear trenches built for military training during the Smoky test.

The area of potential effect for the Smoky project encompasses the site of an atmospheric nuclear test ground zero and, as expected, almost all the recorded cultural resources were associated with this 1957 test. Atmospheric nuclear tests, such as Smoky, comprise about 10% of all nuclear tests at the NNSS. This nuclear testing program was integral to the United States national defense throughout the Cold War era and the NNSS was the continental outdoor laboratory for improving the strategic nuclear defense of the United States and its allies. In general, cultural resources associated with the United States Cold War nuclear testing program have national and international significance, especially nuclear test locations. Also, nuclear testing is one of the themes in the Nevada Comprehensive Preservation Plan provided by the Nevada State Historic Preservation Office. For these reasons, the major sites and structures associated with nuclear testing usually have significance in the history of Nevada and the United States and many are eligible to the National Register of Historic Places.

NATIONAL REGISTER ELIGIBILITY

The Smoky atmospheric nuclear test was conducted in 1957 for weapons related purposes. The test location, designated historic district D104 (discontiguous) and historic archaeological sites 26NY14794 and 26NY14795, is the best preserved post-shot atmospheric nuclear tower test location on the NNSS and possibly the world. Historic district D104 is eligible to the NRHP under Criteria A, B, C, and D of 36 CFR Part 60.4. Archaeological site 26NY14794 (Smoky test area) is eligible to the NRHP under Criteria A, B, C, and D of 36 CFR Part 60.4 and archaeological site 26NY14795 (military trenches) is eligible to the NRHP under Criteria A, C, and D of 36 CRF Part 60.4. Table 7 (at the end of this section) shows the contributing/non-contributing status for the structures and archaeological features along with NRHP eligibility.

The following is a discussion of the four significance criteria in conjunction with an assessment of the aspects of integrity as they pertain to the Smoky cultural resources.

Criterion A

Criterion A refers to events that have made significant contributions to the broad patterns of our history. A number of aspects of the Smoky test location contribute to eligibility under Criterion A. First, the Smoky test was one of a series of nine tower tests on the NNSS during 1957, as part of Operation Plumbbob. These nuclear tests were conducted for weapons related purposes in defense of the United States during the Cold War, a war characterized by competing social, economic, and political ideologies between the United States and the former Soviet Union. Historic archaeological site 26NY14794 is associated with a significant event, the detonation of the nuclear device for the Smoky test on August 31, 1957. Structures used for diagnostic and test effects were an integral part of this test as were military trenches (site 26NY14795) designed for troop observation and maneuvers. Second, participation in the Smoky test had an international component. Projects undertaken by the Service National de la Protection Civile of France and the West German Government through their liaison Ammann & Whitney, Consulting Engineers, evaluated and improved existing designs for underground personnel

shelters. Third, in the mid-1970s, the Center for Disease Control became interested in the rate of leukemia related cases from servicemen who participated in the Smoky test. As a result, the Medical Follow-up Agency of the National Research Council was established and continues to maintain a medical research program related to nuclear testing personnel. On January 15, 1994, President Bill Clinton formed the Advisory Committee on Human Radiation Experiments (ACHRE). ACHRE's final report was a factor in establishing the DOE Office of Human Radiation Experiments that assured publication of DOE’s involvement, by way of its predecessor, the Atomic Energy Commission, in Cold War radiation research on human subjects.

Criterion B

Criterion B applies to properties associated with individuals whose specific contributions to history can be identified and documented. During the Cold War, France and West Germany were allies of the United States and the collaboration between these three countries is exemplified at the Smoky test. This test was only 12 years after the end of World War II. So it is striking to see French and German underground shelters within sight of each other on this nuclear testing site. This level of nuclear testing collaboration between France, Germany, and the United States was unprecedented. French and German government personnel were involved in Smoky in order to test their designs of underground shelters in a cooperative environment and were present throughout the shelters’ construction, detonation, and post-shot evaluation (Ailleret 1968: 241-244. 290-298, 368; Burrows et al. 1989:5). The following describes the context for the participation by the French and highlights the involvement of General Charles Ailleret, the Father of the French atomic bomb.

> To help prepare for France’s first nuclear test, several French delegations came to the U.S. Nevada Test Site in 1957 and 1958 to witness and participate in U.S. nuclear tests. These visits provided an orientation in nuclear test effects, culminating in their participation in the U.S. atmospheric test SMOKY on 31 August 1957, at which the French tested a selection of their underground personnel shelters, equipment, and test instrumentation. The importance of these visits was reflected in the high-ranking French delegates, which included General Charles Ailleret, often referred to as the Father of the French atomic bomb, and General Andre Buchalet, founder and first director of the Military Applications Branch of the French Atomic Energy Commission (Atomic Energy Commission 1958.)

In Figure 30 of this report, this French delegation is shown at one of the French underground shelters and General Charles Ailleret is believed to be the man in sunglasses to the left that is looking down the staircase into the French shelter at Smoky. He was in charge of the French nuclear testing program and the information garnered from involvement in the U.S. nuclear tests was important to the development and execution of the French nuclear testing program. His involvement in the French participation in U.S. nuclear tests at the Nevada Test Site, his oversight of the test experiments and bunker design, and his presence at the Smoky test along with General Andre Buchalet, is of historical importance due to his significance in the history of nuclear testing. French nuclear testing began on February 13, 1960, from a 105 m (344 ft) tower in Reggane, Algeria, and included 48 atmospheric tests (Burrows et al. 1989:3). When

France became the third ranked nuclear power in the world, the cooperation between the U.S. and France during France's early days establishing their nuclear program had long-lived benefits for each country. For Smoky and its relationship to Criterion B, the presence of General Charles Ailleret, the Father of the French Atomic Bomb, is a significant person in the U.S. nuclear testing history. The cooperative nuclear testing situation in the U.S. was an important juncture in the solidification of the Cold War relationships between France, West Germany, and the United States. Although, a comparable level of archival research has been conducted for information on the West German participation in the Smoky test, no documents discussing their activities have been found and their participation is based on engineering drawings and photographs. As a result, the West German involvement is unevaluated for Criterion B, pending securing the appropriate documentation to do this evaluation.

Criterion C

Criterion C applies to properties significant for their physical design or construction, including architecture, landscape architecture, and engineering. There are structures at the Smoky test area that are representative of atmospheric nuclear test engineering and design with some that are unique to the Smoky test. Examples of these are the structures that demonstrate the engineering aspects of the Smoky tower, such as the tower foundation, anchor blocks, and tower stanchions. Other examples of structures developed and built for this atmospheric test are instrument stations designed to use remote techniques to measure nuclear radiation north of the ground zero, the underground Ballistics Research Laboratory station, and a station with stands used for blast wave gauges are indicative of an atmospheric test location. There is one type of structure at the Smoky test location that is distinctive to nuclear testing and the Cold War era. This type is the underground personnel shelter. These underground personnel shelters were tested for their ability to maintain integrity during the Smoky detonation and to obtain the necessary information to improve their construction and integrity for protection of people and materials during a nuclear attack. The French and German underground personnel shelters were test experiments, designed in a style that later became well known as "the bomb shelter" or fallout shelter. Bomb shelters were used during air raids in World War II, but the Cold War shelters also had to be designed to protect the inside area from fallout and to withstand a much larger detonation and shock wave. This style is characterized by an underground reinforced concrete structure with a large room or area that is shielded from a nuclear detonation and radioactive materials by the concrete and earth surrounding it on all sides and it is designed to have the ability to seal the structure from outside air for a limited time period. Both the French and German shelters sustained some damage during the Smoky test and this information was used to improve the safety and durability of the shelters as they were built for military and civil purposes in the 1960s and later. The military trenches at site 26NY14795 were constructed by DOD for military training and troop maneuvers. The layout of the trenches and the construction aspects represent standard DOD designs for troop protection in the battlefield. The trenches constructed for the Smoky test used a standard trench design to train troops how to protect themselves during a nuclear attack.

Criterion D

Criterion D applies to properties that have yielded, or may be likely to yield, information important in prehistory or history. The Smoky atmospheric test area is designated historic district D104 (discontiguous) and this historic district shares its boundaries with site 26NY14794 (ground zero area) and site 26NY14795 (military trenches). The Smoky district and archaeological sites have the potential to provide significant information about the activities conducted at these locations, identified in the research questions presented earlier in this document.

- What is the history of atmospheric nuclear testing facilities at the location?

  Archival research has provided a historic context for the Smoky test as well as information regarding the construction of the test area. Activities included road building, surface grading, and excavations for placement of the tower, concrete anchor blocks, instrumentation, and rebar-reinforced concrete personnel shelters. Development of the infrastructure and test facilities modified the landscape which in turn was subject to a nuclear blast. The recording of these remains in the Smoky atmospheric test area provides ancillary data to support the timeline of the nuclear test, verifies activities at the test location, and documents the history of the post-test detonation. Approximately 60% of the test area has yet to be studied.

- What is the structure of an atmospheric nuclear test site and how does the condition and spatial distribution of post-test remnants compare to this pre-test setup?

  The Smoky test is the only nuclear tower test location that is essentially undisturbed since the day the test was conducted. The force of the Smoky nuclear detonation was a catastrophic depositional event, reshaping the character of the structures, features, artifacts, and terrain. Smoky is an ideal location to investigate the spatial distribution and physical condition of the remains from an atmospheric tower test due to the integrity of the post-test landscape. It has interrelated cultural resources spatially arranged in a pattern informative about the organization of an atmospheric nuclear test. Initial recording identified the distribution of the cultural resources within 40% of the Smoky test area. Artifacts consist of layers of tower components, mechanical equipment, metal fragments, lead bricks, and other nuclear testing materials. Recorded features are concrete blocks, a charcoal scatter, a plywood box, water heater, concrete pad, cable spool, round bar frames, and concrete vent sections. Structures are tower components in the ground zero area, instrument stations for diagnostic tests, concrete shelters for Civil Defense studies, structures used for diagnostic and effects studies, and military trenches. This information indicates that in-depth recording of the known and unrecorded resources would produce additional information regarding the spatial distribution of the remains. Mapping and detailed descriptions of the current condition of all artifacts, features, and structures would be necessary to address this question. This information then could be compared with the pre-test setup because there is little data in archival records regarding the post-shot condition of these resources.

- What is the scientific significance of the nuclear testing remains in the area?

  Due to its post-shot integrity, this Smoky location provides unique scientific information not available elsewhere. Although scientists studied the test data in the immediate years after the detonation, the Smoky test site has the potential to provide scientific evidence for future nuclear scientists regarding the intricacies of this type of a nuclear blast, based on the condition and distribution of its material remains.

Assessment of Integrity

In addition to meeting the National Register Criteria of A, B, C, and D, historic district D104, contributing structures, and archaeological sites 26NY14794 and 26NY14795, retain aspects of location, setting, design, materials, feeling, and association to convey their significance. The series of contributing structures are in their original location. The Smoky post-test setting has been relatively undisturbed since the nuclear test with minimal modification and the artifacts and features maintain their post-test configuration. The instrument stations, personnel shelters, and military trenches retain the historic materials with which they were built and display original workmanship. The engineering design for the test (individually for personnel shelters and instrument stations or collectively for tower components) remains evident. The structures and historic archaeological sites are visually intact and retain integrity of feeling and association with an atmospheric nuclear test. The tower artifacts provide significant physical characteristics conveying a sense of the force of a nuclear detonation. In addition, the French personnel shelters are associated with General Charles Ailleret, the Father of the French atomic bomb. No other atmospheric nuclear properties in the U.S. are known to be associated with Ailleret. The Smoky test area is shaped by the use of the land for the Smoky atmospheric nuclear test and retains visual and cultural characteristics of the pre-test design and construction and the post-test remains. In addition, the historic district and archaeological sites retain sufficient integrity to provide information to address important research questions under Criterion D.

ASSESSMENT OF POTENTIAL EFFECTS

Within the Smoky test area, the following items are scheduled for removal: three empty 10-gallon metal drums, at least three lead acid batteries including lead grid plates and plastic components, and lead acid batteries and battery fragments in a low mound mixed with other items including scrap metal and small electrical equipment pieces. Metal drums and containers are being removed because these items may have contained hazardous materials. Lead acid batteries with lead grid plates are assumed to be potential source materials for environmental contaminants due to their lead content and removal is the selected corrective action for environmental remediation. The metal drums and lead acid batteries are not associated with the Smoky test, but with subsequent activities, and do not relate to the significance of D104 and 26NY14794. Also, the proposed closure of the area with use restrictions will limit access, an action that will contribute to the preservation of this historic location. Given the proposed actions do not involve cultural resources related to the Smoky test, no historic properties will be affected by the proposed undertaking and the Smoky test area will retain its integrity and eligibility to the NRHP. No undertaking is proposed for 26NY14795, the military trenches.

MANAGEMENT RECOMMENDATIONS

The Smoky test location, consisting of two historic archaeological sites (26NY14794 and 26NY14795) and historic district D104, is an irreplaceable cultural resource and is eligible to the NRHP under 36 CFR Part 60.4 Criteria A, B, C, and D. In addition to meeting the eligibility criteria, the cultural resources retain sufficient integrity to convey their significance. The Smoky test area is an invaluable scientific and historic resource for future generations. The Smoky test area should be preserved in place in its current condition. Any removal of cultural resources or disturbance to these historic properties would compromise their integrity and have an adverse effect under the National Historic Preservation Act. Finally, the Smoky test location should be included in the NNSS cultural resources monitoring program in order to document its condition over time and to identify any deterioration or changes to the historic cultural resources.

Table 7. Contributing and Non-Contributing Resources and NRHP Eligibility.

SHPO Resource # or Feature #	Description	Contributing	Non-Contributing	NRHP Eligibility
B12411	Trailer		x	no
S887	T-2c tower foundation	x		*yes
S888	Elevator pit	x		*yes
S889	Elevator hoist pad	x		*yes
S890	Anchor block with attachments	x		**yes
S891	Station 8-22-6001 Cokehill	x		A, C, and D
S892	Station 8-22-6002 Cokehill fluor and converter	x		A, C, and D
S893	Stanchion pair northwest of GZ	x		*yes
S894	Stanchion pair northwest of GZ	x		*yes
S895	Stanchion pair southwest of GZ	x		*yes
S896	Stanchion pair southwest of GZ	x		*yes
S897	Stanchion pair northeast of GZ	x		*yes
S898	Stanchion pair northeast of GZ	x		*yes
S899	Concrete pads and cable anchors	x		**yes
S900	Instrument station	x		A and D
S901	Electrical panel and backboard		x	no
S902	Concrete pad	x		no
S903	Battery vault	x		A, C, and D
S904	Stanchion pair southeast of GZ	x		*yes
S905	Electrical switch boxes and backboard		x	no
S906	French personnel shelter II-4	x		A, B, C, and D
S907	French personnel shelters II-3	x		A, B, C, and D
S908	French personnel shelter II-1	x		A, B, C, and D
S909	French personnel shelter II-5	x		A, B, C, and D
S910	French personnel shelter II-2	x		A, B, C, and D
*Structures are components of the T-2c tower and are eligible to the NRHP under Criteria A, C, and D when evaluated collectively. The resources are not eligible as stand-alone structures.				
**Structures are components of an instrumentation cable system and are eligible to the NRHP under Criteria A, C, and D when evaluated together. The resources are not eligible as stand-alone structures.				

Continued

Table 7. Contributing and Non-Contributing Resources and NRHP Eligibility (continued).

SHPO Resource # or Feature #	Description	Contributing	Non-Contributing	NRHP Eligibility
S911	German personnel shelter RAa	x		A, C, and D
S912	German personnel shelter RAb	x		A, C, and D
S913	German personnel shelter CAa	x		A, C, and D
S914	German personnel shelter RAc	x		A, C, and D
S915	German personnel shelter CAb	x		A, C, and D
S916	German personnel shelter RAd	x		A, C, and D
S917	German personnel shelter RCa	x		A, C, and D
S918	German personnel shelter RCb	x		A, C, and D
S919	Station 8-30.7-8007 Ballistic Research Laboratory	x		A, C, and D
S920	Series of gauge instrument stands	x		A, C, and D
S921	Station 8-22-6003 fluor on concrete pad	x		no
S923	S918 exit shaft and vent stack	x		see S918
S922	Trenches	x		A, C, and D
Feature 1	Concrete blocks	x		Not applicable
Feature 2	Charcoal briquette concentration	x		Not applicable
Feature 3	Plywood box		x	Not applicable
Feature 4	Water heater		x	Not applicable
Feature 5	Concrete pad	x		Not applicable
Feature 6	Cable spool stand	x		Not applicable
Feature 7	Series of bent metal bars	x		Not applicable
Feature 8	Concrete vent section	x		Not applicable
Feature 9	Concrete vent section	x		Not applicable
Feature 10	Concrete vent section	x		Not applicable
Feature 11	Concrete vent section	x		Not applicable
Feature 12	Concrete vent section	x		Not applicable
Feature 13	Concrete vent section	x		Not applicable
Feature 14	Engine parts and a metal grate		x	Not applicable

REFERENCES

Ailleret, Charles
1968 *L'Aventure Atomique Française*. Grasset, Paris, France.

Anders, Roger M.
1978 *Institutional Origins of the Department of Energy*. Energy History Series 1(1), The Office of Military Application, U.S. Department of Energy, Washington, D.C.

Brady, William J., Bernard Eubank, Elizabeth McDowell, and Joe A. Stinson
1989 *Operations Anvil, Cresset, Tinderbox, and Guardian: Events Husky Pup, Mighty Epic, Hybla Gold, Diablo Hawk, Huron King, and Miners Iron, 24 October 1975 - 31 October 1980*. Report DNA 6325F, Field Command, Defense Nuclear Agency, Kirtland Air Force Base, New Mexico.

Burrows, Andrew S., Robert S. Norris, William M. Arkin, and Thomas B. Cochran
1989 *Nuclear Weapons Databook Project Working Paper*. Natural Resources Defense Council, Washington, D.C.

Carothers, James
1995 *Caging the Dragon: The Containment of Underground Nuclear Explosions*. Report DOE/NV 388, Nevada Operations Office, Department of Energy, Las Vegas, Nevada.

Castetter, R.C. and H.O. Hill
1979 Additions to the Birds of the Nevada Test Site. *Western Birds* 10:221-223.

Clerico, Robert L, David D. Ferraro, Cari L. Lockett, and Ronald L. Reno
1982 *Archaeological Reconnaissance of 7 Seismic Lines Located in Yucca Flat*. Cultural Resources Reconnaissance Short Report No. SR070182-1-7, Desert Research Institute, Reno, Nevada.

Cohen, Edward and Norval Dobbs
1962 *Operation Plumbbob - Project 30.6 - Test of French Underground Personnel Shelters*. Report to the Test Director, Ammann & Whitney, New York.

Cohen, Edward and A. Bottenhofer
1962 *Operation Plumbbob - Project 30.7 - Test of German Underground Personnel Shelters*. Report to the Test Director, Ammann & Whitney, New York.

Cosenza, C. J., R. G. Coy, D. A. Kahle, T. E. Pascoe, and P. C. Wing
1961 *Operation Plumbbob - Project 8.3b – Instrumentation for Measuring Effects Phenomena inside the Fireball*. Report to the Test Director. On file at the Nuclear Testing Archive, National Nuclear Security Administration Nevada Field Office, Accession # NV0306343. Las Vegas, Nevada.

Defense Nuclear Agency
1981 Fact Sheet. Plumbbob Series, Defense Nuclear Agency, Washington D.C.

Defense Threat Reduction Agency (DTRA)
2002 *Defense's Nuclear Agency 1947-1997*. Defense Threat Reduction Agency, U.S. Department of Defense, Washington, D.C.

Department of Energy, Nevada Operations Office (DOE/NV)
2000 *United States Nuclear Tests: July 1945 through September 1992*. Report DOE/NV-209 (Revision 15), U.S. Department of Energy, Nevada Operations Office, Las Vegas, Nevada.

2010 *Nevada Test Site History: Plutonium Dispersal Tests at the Nevada Test Site*. Report DOE/NV–1046, U.S. Department of Energy, Nevada Operations Office, Las Vegas, Nevada.

2012 *Corrective Action Investigation Plan for Corrective Action Unit 550: Smoky Contamination Area Nevada National Security Site, Nevada*. Report DOE/NV–1477, U.S. Department of Energy, Nevada Operations Office, Las Vegas, Nevada.

Dohrenwend, John C.
1987 Basin and Range. In *Geomorphic Systems of North America*, edited by W.L. Graf, pp. 303-342. Centennial Special Volume 2, Geological Society of America, Boulder, Colorado.

Drollinger, Harold, Colleen M. Beck, and Nancy Goldenberg
2003 *Historical Evaluations of Control Point Buildings 2, 10, 43, and 400 in Area 6, Nevada Test Site, Nye County, Nevada*. Cultural Resources Reconnaissance Short Report No. SR071602-1, Desert Research Institute, Las Vegas, Nevada.

Drollinger, Harold and Nancy Goldenberg
2004 *An Historical Evaluation of the Super Kukla Control Building, Area 27, Nevada Test Site, Nye County, Nevada*. Cultural Resources Reconnaissance Short Report No. SR042104-3, Desert Research Institute, Las Vegas, Nevada.

Drollinger, Harold, Thomas F. Bullard, Laurence J. Ashbaugh, and Wayne R. Griffin
2007 *A Historical Evaluation of the U12e Tunnel, Nevada Test Site, Nye County, Nevada*. Cultural Resources Technical Report No. 104, Division of Earth and Ecosystem Sciences, Desert Research Institute, Las Vegas, Nevada.

Drollinger, Harold, Nancy Goldenberg, and Colleen M. Beck
2000 *An Historical Evaluation of the Super Kukla Facility in Area 27 for Activities Associated with the Decontamination and Decommissioning Program, Nevada Test Site, Nye County, Nevada*. Cultural Resources Reconnaissance Short Report No. SR021700-1, Desert Research Institute, Las Vegas, Nevada.

Drollinger, Harold, Nancy Goldenberg, and Carin Petersen

2005 *An Historical Evaluation of the Pluto Control Facility, Area 26, Nevada Test Site, Nye County, Nevada*. Cultural Resources Reconnaissance Short Report No. HE041305-1, Desert Research Institute, Las Vegas, Nevada.

Drollinger, Harold, Robert C. Jones, Thomas F. Bullard, Laurence J. Ashbaugh, and Wayne R. Griffin

2009 *A Historical Evaluation of the U12t Tunnel, Nevada Test Site, Nye County, Nevada*. Cultural Resources Technical Report No. 105, Desert Research Institute, Las Vegas, Nevada.

2010 *A Historical Evaluation of the U12n Tunnel, Nevada National Security Site, Nye County, Nevada*. Cultural Resources Technical Report No. 106, Desert Research Institute, Las Vegas, Nevada.

Edwards, Susan R.

1997 *Atomic Age Training Camp: The Historical Archaeology of Camp Desert Rock*. M.A. thesis, Department of Anthropology and Ethnic Studies, University of Nevada, Las Vegas.

Edwards, Susan R. and William G. Johnson

1995 *A Historical Evaluation of Building 2-300, Yucca Flat, Area 2, Nevada Test Site, Nye County, Nevada*. Cultural Resources Reconnaissance Short Report No. SR062095-2, Desert Research Institute, Las Vegas, Nevada.

Fernald, A.T., G.S. Corchary and W.P. Williams

1968 Surficial geologic map of Yucca Flat, Nye and Lincoln Counties, Nevada. *U.S.G.S. Miscellaneous Geological Investigations Map* I-550.

Fradkin, Philip L.

2004 *Fallout: An American Nuclear Tragedy*. Johnson Printing Company, Boulder, Colorado.

Friesen, H.N.

1995 *A Perspective on Atmospheric Nuclear Tests in Nevada: Fact Book*. Report No. DOE/NV 296, U.S. Department of Energy, Nevada Operations Office, Las Vegas, Nevada.

Grayson, Donald K.

1993 *The Desert's Past: A Natural Prehistory of the Great Basin*. Smithsonian Institution Press, Washington, D.C.

Greger, Paul D.

1994 Status of Horses, Deer, and Birds on the Nevada Test Site in 1993. In *Status of the Flora and Fauna on the Nevada Test Site, 1993*, pp. 124-137, Report DOE/NV/11432-162, Reynolds Electrical & Engineering Co., Inc., Las Vegas, Nevada.

Harris P.S., C. Lowery, A.G. Nelson, S. Obermiller, W.J Ozeroff, and E. Weary

1981a *Shot Smoky, A Test of the Plumbbob Series, 31 August 1957*. Report #DNA 6004F, Defense Nuclear Agency, Washington, D.C.

1981b *Plumbbob Series, 1957.* Report #DNA 6005F, Defense Nuclear Agency, Washington, D.C.

Holmes & Narver, Inc.

1957 Drawing # Y8-34.2-8017.01-S3. On file at the Archives and Record Center, Mercury, Nevada.

1958 *Facilities Brochure of the Nevada Test Site for the United States Atomic Energy Commission*. On file at: Nuclear Testing Archive, National Nuclear Security Administration, Las Vegas, Nevada.

Holz, Barbara A.

1992 *A Class III Cultural Resources Reconnaissance of Groundwater Characterization Well EU10j Borrow Pit and Pond Area, Yucca Flat, Area 8, Nevada Test Site, Nye County, Nevada.* Cultural Resources Reconnaissance Short Report No. SR110992-1, Desert Research Institute, Las Vegas, Nevada.

Holz, Barbara A. and Sabra E. Gilbert

1992 *A Class III Cultural Resources Reconnaissance of the Realignment of the Ue10j Skid Lane, Yucca Flat, Area 8, Nevada Test Site, Nye County, Nevada*. Desert Research Institute Cultural Resources Short Report SR041092-2, Las Vegas, Nevada.

Houghten, Richard A. and Richard B. Harvey

1958 *Operation Plumbbob - Project 6.4 - Accuracy and Reliability of a Short-Baseline NAROL System*. Air Force Cambridge Research Center, Bedford, Massachusetts.

Johnson, G.

1957 *Test Director's Report on Operation Plumbbob.* Radiation Laboratory, Livermore Site. Livermore, California. On file at the Nuclear Testing Archive, National Nuclear Security Administration Nevada Field Office, Accession # NV 0133206. Las Vegas, Nevada.

Johnson, Gerald W., Gary H. Higgins, and Charles E. Violet

1959 *Underground Nuclear Detonations*. Report UCRL-5626, Lawrence Radiation Laboratory, University of California, Livermore.

Johnson, William G.

1992 *A Class III Cultural Resources Reconnaissance of the Proposed Groundwater Characterization Well Ue-10J and associated access road, Yucca Flat, Area 8, Nevada Test Site, Nye County, Nevada*. Cultural Resources Reconnaissance Short Report No. SR030992-1, Desert Research Institute, Las Vegas, Nevada.

1994 *A Historical Evaluation of the Area 2 Equipment Support Yard, Yucca Flat, Area 2, Nevada Test Site, Nye County, Nevada*. Cultural Resources Reconnaissance Short Report No. SR020894-1, Desert Research Institute, Las Vegas, Nevada.

2002 *A Historical Evaluation of the T-3b Fizeau Bunker, Area 3, Nevada Test Site, Nye County, Nevada*. Cultural Resources Reconnaissance Short Report No. SR082201-1, Desert Research Institute, Las Vegas, Nevada.

Johnson, William G. and Susan R. Edwards

1996 *Historic American Buildings Survey Documentation of the Japanese Village on the Nevada Test Site*. Historic American Building Survey No. NV-27, U.S. National Park Service, Washington, D.C.

2000 *Survival Town: The Apple-2 Historic District, Nevada Test Site, Nye County, Nevada*. Cultural Resources Technical Report No. 99, Division of Earth and Ecosystem Sciences, Desert Research Institute, Las Vegas, Nevada.

Johnson, William G., Barbara A. Holz, and Robert Jones

2000 *A Cold War Battlefield: Frenchman Flat Historic District, Nevada Test Site, Nye County, Nevada*. Cultural Resources Technical Report No. 97, Division of Earth and Ecosystem Sciences, Desert Research Institute, Las Vegas, Nevada.

Jones, Robert C.

2003 *Historical Evaluation of Kay Blockhouse, Frenchman Flat, Area 5, Nevada Test Site, Nye County, Nevada*. Cultural Resources Reconnaissance Short Report No. SR030703-1, Desert Research Institute, Las Vegas, Nevada.

2003 *A Class III Cultural Resources Reconnaissance of the Proposed a Soil Stabilization Demonstration Project, Area 8, Nevada Test Site, Nye County, Nevada.* Cultural Resources Reconnaissance Short Report No. SR070903-1, Desert Research Institute, Las Vegas, Nevada.

2004 *A Historical Evaluation of Station 7-800 in Area 7, Nevada Test Site, Nye County, Nevada*. Historical Evaluation Short Report HE042004-1, Desert Research Institute, Las Vegas, Nevada.

2005 *An Inventory of Benches at Viewing Points for Atmospheric Nuclear Testing Events at the Nevada Test Site, Nye County, Nevada*. Cultural Resources Inventory Report SR020904-1, Desert Research Institute, Las Vegas, Nevada.

Jones, Robert C., Thomas F. Bullard, and Colleen M. Beck
2006 *Historical Evaluation of U12b Tunnel Complex in Area 12, Nevada Test Site, Nye County, Nevada.* Desert Research Institute Historical Evaluation Report No. HE0106-1, Las Vegas, Nevada.

Jones, Robert C., Colleen M. Beck, and Barbara A. Holz
2005 *Yucca Lake Historic District, Area 6, Nevada Test Site, Nye County, Nevada*. Cultural Resources Technical Report No. 102, Desert Research Institute, Las Vegas, Nevada.

Jones, Robert C. and Harold Drollinger
2001 *A Class III Cultural Resources Reconnaissance of the Proposed Underground Test Area Seismic Lines in Frenchman Flat, Nevada Test Site, Areas 5 and 11, and Nellis Air Force Range, Nye County, Nevada*. Cultural Resources Reconnaissance Short Report SR060401-1, Desert Research Institute, Las Vegas, Nevada.

Jones, Robert C., Harold Drollinger, Thomas F. Bullard, Laurence J. Ashbaugh, and Wayne R. Griffin
2012 *A Historical Evaluation of the U-16a Tunnel, Nevada National Security Site, Nye County, Nevada*. Cultural Resources Technical Report No. 107, Desert Research Institute, Las Vegas, Nevada.

Lay, James S., Jr.
1950 *Memorandum for the President from the National Security Council, December 18, 1950*. Manuscript on file, Accession No. 304388, Nuclear Testing Archive, U.S. Department of Energy, Nevada Site Office, Las Vegas.

Loeber, Charles R.
2002 *Building the Bombs: A History of the Nuclear Weapons Complex*. Sandia National Laboratories, Albuquerque, New Mexico.

Maag, Carl and Jean Ponton
1981 *Shots Diablo to Franklin Prime, The Mid-Series Tests of the Plumbbob Series 15 July - 30 August 1957*. DNA Report # 6006F, Defense Nuclear Agency, Washington, D.C.

Maag, Carl, Stephen Rohrer, and Robert Shepanek
1982 Operation Ranger: Shots Able, Baker, Easy, Baker-2, Fox. DNA Report # 6022F, Defense Nuclear Agency, Washington, D.C.

Malik, J.S., R.R. Brownlee, C.F. Costa, H.F. Mueller, and R.W. Newman
1981 *Radiological Criteria for Underground Nuclear Tests*. Report LA-8776-MS, Los Alamos Scientific Laboratory, New Mexico.

Medica, P.A.
1990 Noteworthy Mammal Distribution Records for the Nevada Test Site. *Great Basin Naturalist* 50(1):83-84.

Mifflin, M.D. and M.M. Wheat

1979 *Pluvial Lakes and Estimated Pluvial Climates of Nevada*. Bulletin No. 94, Nevada Bureau of Mines and Geology, Mackay School of Mines, University of Nevada, Reno.

Nevada Test Organization

1957 Background Information on Nevada Nuclear Test. May 1, 1957, Office of Test Information, Las Vegas, Nevada.

Ogle, William E.

1985 *An Account of the Return to Nuclear Weapons Testing by the United States after the Test Moratorium 1958-1961*. U.S. Department of Energy, Nevada Operations Office, Las Vegas. (Redacted version).

O'Farrell, Thomas P. and LaVerne A. Emery

1976 *Ecology of the Nevada Test Site: A Narrative Summary and Annotated Bibliography*. U.S. Energy Research and Development Administration, Technical Information Service, Springfield, Virginia.

Ostler, W. Kent, Dennis J. Hansen, David C. Anderson, and Derek B. Hall

2000 *Classification of Vegetation on the Nevada Test Site*. Bechtel Nevada Ecological Services, Las Vegas, Nevada.

Peterson, F.F.

1988 Appendix B, Consultant’s Report: Soil-Geomorphology Studies in the Crater Flat, Nevada Area. In *Quaternary Geology and Active Faulting at and near Yucca Mountain*, edited by Bell, J.W., Nevada Bureau of Mines and Geology, Reno.

Pippie, Lonnie C.

1982 *Class III Cultural Resources Reconnaissance of Area 10 Looksee Site at Ue10aa, Yucca Flat, Nye County, Nevada.* Cultural Resources Reconnaissance Short Report No. SR113082-1, Desert Research Institute, Las Vegas, Nevada.

Ponton, Jean, Carl Maag, Mary Francis Barrett, and Robert Shepanek

1982 *Operation Tumbler-Snapper 1952.* Technical report DNA 6019F, prepared by JRB Associates, McLean Virginia, for the Defense Nuclear Agency, Washington, D.C.

Reno, Ronald L.

1983 Class III Cultural Resources Reconnaissance of an Expansion of Drill Pad U10CA, Yucca Flat, Nevada Test Site. Cultural Resources Reconnaissance Short Report No. SR012583-1, Desert Research Institute, Las Vegas, Nevada.

Reno, Ronald L. and Lonnie C. Pippin

1985 *An Archaeological Reconnaissance of Yucca Flat, Nye County, Nevada.* Technical Report No. 35, Social Sciences Center, Desert Research Institute, Reno, Nevada.

Robinette, C. Dennis, Seymour Jablon, and Thomas L. Preston
1985 Mortality of Nuclear Weapons Test Participants: Studies of Participants in Nuclear Tests. Medical Follow-Up Agency, National Research Council, Washington, D.C.

Schraut K.C. and L.J. Breidenbach
1953 *Vulnerability of Parked Aircraft to Atomic Bombs*. AEC Technical Information Service, Oak Ridge, Tennessee.

Slate, Janet L., Margaret E. Berry, Peter D. Rowley, Christopher J. Fridrich, Karen S. Morgan, Jeremiah B. Workman, Owen D. Young, Gary L. Dixon, Van S. Williams, Edwin H. McKee, David A. Ponce, Thomas G. Hildenbrand, W.C. Swadley, Scott C. Lundstrom, E. Bartlett Ekren, Richard G. Warren, James C. Cole, Robert J. Fleck, Marvin A. Lanphere, David A. Sawyer, Scott A. Minor, Daniel H. Grunwald, Randell J. Laczniak, Christopher M. Menges, James C. Yount, and Angela S. Jayco
1999 Digital geologic map of the Nevada Test Site and vicinity, Nye, Lincoln, and Clark Counties, Nevada, and Inyo County, California. U.S. Department of the Interior, Washington, D.C.

Stapp, Darby C.
1997 Documenting a Cold War Nuclear Reactor: Attempting Innovation. *CRM* 20(13):38-40.

Taylor, E.M.
1986 *Impact of Time and Climate on Quaternary Soils in the Yucca Mountain Area of the Nevada Test Site*. M.S. thesis, University of Colorado, Boulder.

Titus, A.C.
1986 *Bombs in the Backyard: Atomic Testing and American Politics*. University of Nevada Press, Reno.

Tlachac, E.
1991a Nuclear Testing. In *Nevada Comprehensive Preservation Plan*, edited by W.G. White, R.M. James, and R. Bernstein, pp. 25/1-25/12. Division of Historic Preservation and Archaeology, Department of Conservation and Natural Resources, Nevada Historical Society, Department of Museums and History, Carson City, Nevada.

1991b Operating Plan. In *Nevada Comprehensive Preservation Plan*, edited by W.G. White, R.M. James, and R. Bernstein, pp. 25/13-25/24. Division of Historic Preservation and Archaeology, Department of Conservation and Natural Resources, Nevada Historical Society, Department of Museums and History, Carson City, Nevada.

U.S. Atomic Energy Commission (AEC)
1958 Press release LAV-58-17, dated February 17, 1958. On file at the Nuclear Testing Archive, National Nuclear Security Administration Nevada Field Office, Accession # NV0324590. Las Vegas, Nevada.

U.S. Department of Energy (DOE/NV)
1957 Instrument Chart Operation Plumbbob. Department of Energy Nevada Test Organization. On file at the Nuclear Testing Archive, National Nuclear Security Administration Nevada Field Office, Accession # NV0133205. Las Vegas, Nevada.

1997 *Linking Legacies: Connecting the Cold War Nuclear Weapons Production Processes to their Environmental Consequences*. Report DOE/EM-0319, Office of Environmental Management, U.S. Department of Energy, Washington, D.C.

2012 *Corrective Action Investigation Plan for Corrective Action Unit 550: Smoky Contamination Area Nevada Nuclear Security Site, Nevada*. DOE/NV--1477, U.S. Department of Energy, National Nuclear Security Administration, Nevada Site Office, Las Vegas, Nevada.

U.S. Nuclear Regulatory Commission (U.S.NRC)
2014 REM (Roentgen equivalent man). Electronic document, http://www.nrc.gov/reading-rm/basic-ref/glossary/rem-roentgen-equivalent-man.html, accessed September 24, 2014.

Wesling, J.R., T.F. Bullard, F.H. Swan, R.C. Perman, M.M. Angell, and J.D. Gibson
1992 *Preliminary Mapping of Surficial Geology of Midway Valley, Yucca Mountain, Nye County, Nevada*. Report SAND91-0607, Sandia National Laboratories, Albuquerque, New Mexico.

White, W., R. James, and R. Bernstein
1991 *Nevada Comprehensive Preservation Plan* edited by W. White, R. James, and R. Bernstein. Nevada Division of Historic Preservation and Archaeology, Department of Conservation and Natural Resources, Nevada Historical Society, Department of Museums and History, Carson City.

Whitney, J.W., R.R. Shroba, R.W. Simonds, and S.T. Harding
1986 *Recurrent Quaternary Movement on the Windy Wash Fault, Nye County, Nevada*. Volume. 18, Geological Society of America Abstracts with Programs.

Wolff, Walter P.
1984 *A Typical Los Alamos National Laboratory Underground Nuclear Test*. Mini-Review LALP-84-47 Revision C.1, Los Alamos National Laboratory, Los Alamos, New Mexico.

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